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ACADEMIC FREEDOM IN A DEMOCRACY

REFERENCE has been made in these columns more than once to the statement issued by the American Association of Universities on the rights and responsibilities of universities*. Their freedom—their duty to pursue the truth wherever investigation may lead—is extended also to the realm of teaching; there should be no curb on freedom of expression in the class-room. The university student should be exposed to competing opinions and beliefs in every field, so that he may learn to weigh them and to gain maturity of judgment. To curb such freedom of teaching, in the hope of avoiding criticism, would be to distort the true process of learning and to deprive society of its benefits.

In arguing here for the recognition and expression of honest differences of opinion, and that the university supplies a distinctive forum for such expression which should, moreover, provide the security which unorthodoxy may sometimes require, the Association joins other stout champions of dissent like Dr. J. B. Conant and Prof. A. Macbeath; but it does not fail also to insist that if there is a duty of utterance and a privilege of freedom to do so, there is also a duty of loyalty to professional ideals and to society. The word 'university' is historically a guarantee of standards, endorsing not the views of its members, but their capability and integrity. The scholar has a heavy responsibility to weigh the validity of opinions and the manner in which they are expressed, and to avoid public acts or utterances which may adversely affect his profession, his university or the general welfare. The greater the autonomy he enjoys through his position in a university faculty, the greater is his responsibility to the public.

With the more specific references of the statement to the position of the universities in the United States as regards the security and loyalty investigations we need here be no further concerned than to note that reliance is placed on public opinion to check the abuse of powers of legislative inquiry, and that the responsibility for academic discipline where necessary is regarded as one for the faculty itself. It is accepted that appointment to a university position and the retention of such an appointment involve not only professional competence but also the affirmative obligation of diligent and loyal citizenship. A scholar must possess integrity and independence, and in the Association's view any kind of clandestine or conspiratorial activity is precluded.

While the statement may go a little too far in its remarks about the duty of candour and the acceptance of conventions, it puts its finger on the essential difficulty in the employment of an avowed communist in a university. It is difficult, if not impossible, to reconcile adherence to communism and its demand for the surrender of the duty of independent criticism with loyalty to the professional ideal and the unflinching and impartial search for truth which mark

*The Rights and Responsibilities of Universities and their Faculties: a Statement by the Association of American Universities, adopted Tuesday, March 24, 1953. Pp. 16. (Princeton, N.J.: Dept. of Public Relations, Princeton University, 1953.)

the scholar. If a university teacher in his class-room becomes a protagonist of one opinion, silences criticism or impairs freedom of thought or expression, he forfeits, in the view of the Association, not only all university support but also his right to membership of a university.

In this view the Association of American Universities is in line with Sir Walter Moberly; but none the less it does not countenance the indiscriminate condemnation of any member of a faculty who may be suspected of communist leanings. Unless he has violated a law, his discipline is solely a university affair and not a political responsibility, and while the statement claims no special privileges in law for university teachers it insists that they should not be subject to special discrimination. Such discrimination, if in the form of special loyalty tests applied to members of a university faculty but not to other people, does harm to the individual and even greater harm to his university and to the whole cause of education by destroying faith in the ideals of university scholarship.

In the face of such a firm—and by no means isolated—protest, it is not easy for a British observer to judge how far the loyalty inquiries in the United States have undermined public confidence there in the integrity and impartiality of the universities. Despite the implications of remarks on university education in the Labour Party manifesto "Challenge to Britain", there is as yet little reason to believe that academic integrity and independence in Great Britain are seriously doubted in any responsible quarters, though it is evident that public understanding of the reasons why academic freedom is so important is far from complete. Without, however, that general understanding, the universities can scarcely make their full contribution in public life to-day.

It was well expressed by the U.S. President's Commission on Higher Education: "A prime essential of a free society is academic freedom. Without it there can be no real profession of teaching or research. Pressure to bend or twist truth, to stay away from controversial issues about which the professor is competent to speak, and to avoid certain areas of inquiry, are not compatible with the ideal of professional integrity. A democratic society has a grave responsibility for maintaining free and untrammelled the avenues of communication". And it may be added that if a university is indeed to be not merely a place where the criticism and evaluation of ideas are continually being carried forward, but also where nonsense can be exposed for what it is, and the intellectual virtues rooted in sincerity of mind fostered and transmitted, a firm guarantee of academic freedom for the individual is essential.

Nor have the universities a more vital function to fulfil in the world to-day than this exposure of humbug and the keeping of public discussion uninhibited, searching, fair-minded and tolerant. Even more important than the direct contribution which individual members of a university may be able to make to the discussion of particular problems within their own special competence is the contribution which the university makes indirectly by supplying the community continuously with minds trained to handle public issues imaginatively, justly and impartially, as well as with technical knowledge and skill. It was apparent from the discussions at the recent Universities' Congress, particularly in that on higher technological education, that there is some concern as to whether the new education of this scientific age is good enough at producing the sound, rounded and cultivated minds that are so important.

"Nothing," said Sir Richard Southwell, in a recent address to the Royal Society of Arts, "could be more disastrous to our industries than deprival of our engineers-in-embryo of the wider outlook and the growth in tolerance that come from informal association with men of other disciplines"; but failure on the part of the university to-day to develop that outlook and toleration is not entirely due to excessive specialization. It can equally be due, as the University Grants Committee has noted, to the lack of cultural background in the home, and the increasing proportion of students who have no such breadth of cultural experience behind them as a good professional home of a generation or more ago provided makes it all the more important that the universities should explore urgently and assiduously the possibilities of making good this deficiency.

A prime purpose of the University College of North Staffordshire, under the late Lord Lindsay's guidance, was to experiment in the provision of men and women with a broad general training. Sir John Lennard-Jones, in his inaugural address delivered last May, made it clear that he is pursuing the experiment, and that this attempt to provide the intending scientist with a broad cultural background and at the same time to give students of the arts and social subjects some idea of the aims, methods and achievements of the scientist will be resolutely continued. It will be noted that in this address Sir John referred again to the importance of the university teacher, as a privileged member of society, demonstrating by teaching and example the ideal of the educated man. He, too, called for integrity of mind and fearless honesty in following the argument wherever it leads, irrespective of prejudice and preconceived ideas, for the recognition of essentials in a train of thought or discussion and the ability to reject the secondary or irrelevant, and for accuracy and clarity of exposition.

The responsibility, however, rests on professional associations and institutions as well as on the universities. Moreover, though it is on his own personal integrity and judgment that the professional man or scholar must rely when he takes his stand on some issue within his competence and resists any external pressure to warp or distort his judgment, it is, as Carr-Saunders and Wilson have pointed out, from within his professional organization that he will find the anchorage and support that may make his stand effective. Independent centres of reflexion, criticism and judgment are essential for the health of the community. With startling prescience Sir Michael Sadler wrote in 1901 in his special report "Unrest in Secondary Education in Germany and Elsewhere": "If a highly centralised State once gets

a grip on the conditions of intellectual life, those who act on behalf of the State are apt to discourage freedom of discussion and what matters far more, freedom of social and educational experiment".

In this issue of academic freedom the position of the professional organization is, in fact, linked with that of the university. Freedom of utterance of criticism and discussion are for them the counterpart of academic freedom, and the more so as the universities follow Sir Hector Hetherington's plea and give sovereign place to the educational rather than the professional ideal. No matter how successfully the universities may foster the unforced, informal, invigorating education which comes from the mutual impact of minds of different ancestry and interest, it will rest with the professional institution to put the final sharpening edge on the professional experience of the graduate when he goes out to practise his skill in industry or elsewhere.

For the professional institution to exert its full influence, however, its integrity must command the same public confidence as that of the university. A professional institution, either corporately or through its individual members, may well have a public duty to pronounce upon technical or professional aspects of public affairs in which there may be acute controversy. To do so effectively it must command respect for its candour, sincerity and fairness of mind. It must manifestly confine its representations to matters to which its members are competent to give, and have given, serious and informed consideration, and must present fully and faithfully all the evidence relevant to a decision.

What is clear above all to-day is that the values which both the university and the professional ideal assert are precisely those most essential to the functioning of a democratic society which Sir Ernest Barker has described so clearly—a society in which the energies of personal freedom are restrained by mutual respect, which is based, therefore, on equality under a public law, the virtues of which include toleration, sincerity and humility of spirit and which functions by persuasion and discussion and accommodation as opposed to intransigence, rejecting all claims to dogmatic authority. The defence of academic freedom and of professional ideals and traditions is part of the defence of democracy itself.

PRACTICE OF ASSAYING IN THE SIXTEENTH CENTURY

Lazarus Ercker's Treatise on Ores and Assaying
Translated from the German edition of 1580 by Anneliese Grünhaldt Sisco and Cyril Stanley Smith. Pp. xxxiii+360. (Chicago: University of Chicago Press; London: Cambridge University Press, 1951.) 75*s*. net.

IN 1683 one of those large folios so favoured by seventeenth-century writers was published in London, with the title "Fleta Minor". The author was Sir John Pettus, and his book was the first translation into English of Lazarus Ercker's famous treatise on the assaying of metalliferous ores, which had first appeared, in German, at Prague in 1574. Pettus was a deputy governor of the Society of the Mines Royal, and had published, in 1670, "Fodinæ Regales", a history of the chief mines and mineral works in England, Wales and Ireland. It is probable that his translation of Ercker's work, in later German editions entitled "Aula Subterranea", was made originally for the Society of the Mines Royal, but its appearance in print seems to have been due to the interest taken in the matter by the Royal Society. Preparations for publication were actually carried out in the Fleet prison for debtors, in which Pettus had the misfortune to spend the closing years of his life; hence the title and the dedication to, among others, the Warden of the Fleet.

"Fleta Minor" is now an uncommon book, and, in any event, it does not appear that Pettus was specially skilled in the German language, so that the issue of a new and scholarly translation is welcome. This has been prepared through the happy collaboration of a linguist, Mrs. A. G. Sisco, and a distinguished metallurgist, Dr. C. S. Smith, director of the Institute for the Study of Metals in the University of Chicago. It may be remembered that a similar joint effort on the part of Dr. Smith and Dr. Martha T. Gnudi gave us the first complete translation into English of another metallurgical classic, Biringuccio's "Pirotechnia" (*Nature*, 151, 569; 1943); and that Dr. Smith and Mrs. Sisco also collaborated in producing translations of two other well-known sixteenth-century books, one on mining geology and the other on assaying ("Bergwerk und Probierbuchlein". New York: American Institute of Mining and Metallurgical Engineering, 1949).

Ercker signs the preface of his book as chief superintendent of mines and comptroller in the kingdom of Bohemia, and dates it from St. Annenberg (Annaberg in the Saxon Erzgebirge, a district for centuries a centre of mining activity. He lived in an age when the transition from ancient to modern science was just beginning, though upwards of two centuries were to elapse before chemical and physical theory was sufficiently advanced to have any practical application in assaying, which was then, and for a very long time afterwards, purely an empirical art. Ercker, there is reason to believe, was a man of judgment, and well informed about his subject. He was not an alchemist, but an accurate recorder of facts. His observations were made from the point of view of their utility in metallurgical practice, without the intention of theorizing about them. It is this that gives his book its particular value. The esteem in which the book was held may be surmised from the fact that eight editions in German appeared between 1574 and 1736, that the original English translation was twice reprinted, and that a Dutch translation was published as late as 1745. Bibliographical particulars and reproductions of the title pages of all these editions are given in an appendix to the new translation.

If this book is read in conjunction with the Hoover translation of Agricola's "De Re Metallica" and the English edition of Biringuccio's "Pirotechnia" referred to above, it is possible to form a complete and detailed picture of sixteenth-century metallurgical practice. The interest of Ercker's account is enhanced by the illustrations of the processes described, about forty in number, and these have been very well reproduced in the translation. The text is also enriched by a historical introduction by Dr. Smith, the bibliographical appendix already mentioned, a

short account of the life of Sir John Pettus (reproduced from a manuscript in the possession of one of the translators), a note on the system of weights and measures used by Ercker, and an extensive list of the reference works used by the translators in preparing this edition.

It may come as a surprise to readers versed in modern assay practice to find how little change there was in assaying techniques for three centuries following Ercker's time; and even to-day, Dr. Smith states, the assay of gold and silver ores is conducted in almost exactly the same manner as that described by Ercker, with similar implements. The book has, however, a wider interest, for the light it throws on the practical knowledge of chemistry that existed among these old assayers, often quantitative as well as qualitative. They were establishing a tradition of accurate measurement and, at the same time, accumulating data later to be used in the formulation of chemical theories.

Here, then, is a book which should appeal not only to the student of early technology, but also to those interested in the development of chemistry and metallurgical practice. It is an important addition to the list of definitive translations of early scientific classics. Finally, a word of praise is due to the publishers, the University of Chicago Press, whose use of large clear type and fine paper has resulted in the production of a very attractive book.

LIFE-HISTORY OF MARINE FAUNAS

Zoogeography of the Sea

By Sven Ekman. Translated from the Swedish by Dr. Elizabeth Palmer. (Text-Books of Animal Biology.) Pp. xiv+417. (London: Sidgwick and Jackson, Ltd., 1953.) 42*s*. net.

MARINE zoogeography is an exacting but absorbing aspect of oceanography. A critical awareness of the extent of marine investigations and an understanding of systematic zoology are first needed. But the zoogeographer should have a good knowledge of physical oceanography, climatology, submarine geology and palæontology. In Prof. Sven Ekman's "Tiergeographie des Meeres", published in Leipzig in 1935, these sciences were brought to bear on the problems of distribution: the well-reasoned synthesis which emerged needs little introduction to marine biologists.

In this very welcome English edition Prof. Ekman has revised the text and brought it up to date, and Dr. Elizabeth Palmer has made the translation from the Swedish. Here and there a sentence reads awkwardly or quaintly; but the main impression is that justice has been done to Ekman's lucid writing. There are a number of printing errors, although none is serious. On p. 368 *Japetella diaphana* is referred to as a squid: it is an octopod.

Since 1935 there have been many developments in oceanography: about a quarter of the bibliography (598 references) consists of papers published during or after that year. Reports on the work of expeditions have greatly added to knowledge of deep-water zoogeography, particularly those dealing with the investigations of the *Dana*, *Meteor*, *Discovery II*, *William Scoresby* and *Mabahiss*. Russian work in the Arctic and in the seas of the North Pacific has thrown new light on the relationships of the marine faunas. The ecological surveys of the intertidal regions of South Africa and North America by Stephenson and his colleagues have clearly revealed the faunal components and their correlation with hydrological conditions. These more recent investigations and many others have become integral parts of the book, together with relevant developments in physical oceanography.

The assimilation of recent research has also led to a more objective approach. In the English edition there is a greater precision of method, partly seen in the increased use of analytical tables giving a measure of the degree of endemism of a fauna and other features of its composition. Ekman is careful to add that the tables also reflect present limited knowledge. But within the limitations, the tables are handled convincingly. Quite the most interesting sections—and these make up much of the book—develop from the statistical comparisons of faunas and a disciplined yet flexible use of the findings of related sciences in tracing relationships. Ekman sees a fauna as a living unit which changes with time. "The attempt, by growing refinement of method, to find out more and more of the life history of these faunas provides a particular stimulus for the zoogeographer."

Oceanography has grown rapidly since the Second World War; and the publishers, editor and author are to be thanked for the timely production of this valuable book. The "Tiergeographie des Meeres" has been a stimulating guide to many marine biologists; the "Zoogeography of the Sea" will extend this influence and provide an even broader background against which specialists can view their work. In so doing they are likely to agree with Prof. Ekman ". . . that even today, when an ever increasing specialisation is often a condition of progress, there are still sciences left which find in the opening up of frontiers and in the collaboration with other sciences the conditions for their own progress".

N. B. Marshall

CHEMOTHERAPY OF MAN AND ANIMALS

The Sulphonamides and Antibiotics in Man and Animals

By Dr. J. Stewart Lawrence and Prof. John Francis; with the assistance of Dr. Arnold Sorsby and Dr. Philip G. Scott. Second edition. Pp. xii+482+10 plates. (London: H. K. Lewis and Co., Ltd., 1953.) 42*s*. net.

THE discovery of the sulphonamides and antibiotics has revolutionized medical practice. Whereas sixteen years ago chemotherapy was restricted to malaria, amœbic dysentery, syphilis and a handful of tropical diseases, there is now scarcely a single bacterial infection which has not at some time been amenable to treatment. Dr. J. Stewart Lawrence and Prof. John Francis and their colleagues have set themselves the difficult task of providing a guide to the use of these new drugs in the treatment of bacterial infections in man and animals. The plan which they have adopted in this book, which is the successor to the first edition dealing with sulphonamides, is, after a discussion of general principles, to pass to the sulphonamides in general and individually, and from there to a separate chapter on drugs used

for the treatment of leprosy and tuberculosis, the sulphones, thiosemicarbazones and *para*-aminosalicylic acid. Antibiotics in current use, penicillin, streptomycin, neomycin, chloramphenicol, and aureomycin and terramycin are considered next, and most of the remainder of the book is devoted to a discussion of the clinical use of all these agents.

To cover so much ground in a single volume requires careful designing and care in the selection of material, and the authors have succeeded in producing a clear and readable guide to modern practice. The section on veterinary chemotherapy is an interesting account of this young but rapidly expanding field, and is a reminder that the value of the sulphonamides and antibiotics is by no means confined to the treatment of human patients.

In one respect the authors have been handicapped in a way which is almost inevitable. The position of the sulphonamides is established, but new antibiotics are being discovered, and there is still much to be learnt about current ones, and much may happen in the interval between writing and publishing a book. This is perhaps most noticeable here in the sections concerned with bacterial resistance. Recent experience has shown that the development of resistance by bacteria to chemotherapeutic agents is a pressing problem, which more than anything else threatens to nullify the value of the majority of drugs which we now have, and for which a solution is urgently needed. In future editions the effect of this change, and particularly the increase of penicillin-resistant staphylococci, will require restating.

R. A. Shooter

THE ASTRONOMICAL OBSERVATORIES OF JAI SINGH

Maharaja Sawai Jai Singh II of Jaipur and his Observatories

By M. F. Soonawala. Pp. x+44. (Jaipur: Jaipur Astronomical Society, 1952.) 2 rupees.

THE astronomical observatories built by the Maharaja Jai Singh II at Delhi, Jaipur, Ujjain and Benares during the second quarter of the eighteenth century are familiar to visitors to these cities. A fifth observatory, which he built at Mathura, no longer exists. The great masonry instruments, generally similar in design at each of the observatories, have no counterpart elsewhere. They are impressive and curious. Jai Singh had the mistaken idea that large fixed instruments of great stability were necessary in order to obtain accuracy; he thought that with small movable instruments the errors of graduations, the wear in pivots and bearings, and the instability of mounting must result in appreciable errors of observation.

Full descriptions of the observatories, and of the design and principles of the instruments, have been given in G. R. Kaye's excellently illustrated monograph, "The Astronomical Observatories of Jai Singh", published by the Archæological Survey of India in 1918. The volume under review has been published by the Jaipur Astronomical Society, which was founded in September 1948; it has a foreword by the Maharajah of Jaipur.

Jai Singh lived during a very disturbed and troubled period of Indian history, and it is remarkable that in such a time he was able to concern himself with astronomy and to build five observatories. In this book an account is given of his life and of the astronomical contacts between India and Western Europe. This is followed by an elementary explanation of the principles of spherical astronomy which are needed for understanding the design of Jai Singh's instruments. The instruments themselves are described in a final chapter, in which photographs of many of them are reproduced.

The Jaipur Astronomical Society is to be commended for the publication of this moderately priced guide. It will help visitors to these old observatories who have no knowledge of spherical astronomy to understand the design and use of the instruments; but it has also a wider interest as an account of a strange side-track in astronomical instrumentation.

Harold Spencer Jones

ENGINEERING ASPECTS OF ACOUSTICS

Musical Engineering

An Engineering Treatment of the Interrelated Subjects of Speech, Music, Musical Instruments, Acoustics, Sound Reproduction and Hearing. By Dr. Harry F. Olson. Pp. ix+369. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 55*s*. 6*d*.

A NUMBER of books have appeared in recent years the purpose of which is to expound to musicians the recent notable advances in acoustics. Their content has been mainly physics, perhaps with an admixture of physiology; but the present volume is unusual in that, as the title indicates, it purports to deal with the subject as a branch of engineering and so emphasizes those parts of technical acoustics in which are comprised building acoustics and sound reproduction. Besides this, the fundamentals of sound, vibrating systems, speech and hearing are covered in outline.

Less usual in books on this subject, there is a brief description with typical acoustic spectra of all the modern orchestral instruments, but surprisingly—because this is where the author could have made his text distinct from that of 'non-musical' books on applied acoustics—little or no mention of the considerable amount of research done in Europe and the United States in the past twenty-five years on the physics of the functioning of such instruments. Considering that in other sections the information is quite up to date, a similar treatment might have been expected of the advances in this field, which at the present time are having their effect in the musical instrument industry. One would have liked, too, more than the four pages which the author feels sufficient to cover electrophonic instruments, 'electronic organs', and the like.

From the point of view of the scientist interested in music, the presentation is excellent. The treatment is non-mathematical, mainly by clear illustrations, while analogues in alternating-current engineering (circuit diagrams) are given whenever possible.

How far musicians without scientific training will be interested in a book of this type is difficult to say; but one imagines such people will still look for technical guidance to the standard works on harmony and orchestration. Indeed, Dr. Olson and his publisher are not helped by the artist of the wrapper, who in a short four-note specimen of musical notation has perpetrated an equal number of musical solecisms; surely a record!

E. G. Richardson

AN INTERNATIONAL LABORATORY FOR NUCLEAR RESEARCH

ON July 1, a Convention was signed in Paris for the establishment of a European Organization for Nuclear Research. Representatives of twelve European nations took part in the ceremony, and the Convention will take effect when the signatures have been ratified by the Governments of Switzerland, the host country, and six other nations. In the words of the Convention, the purpose of the Organization is to "Provide for co-operation among European states in nuclear research of a pure scientific and fundamental character and in research essentially related thereto. The Organization shall have no concern with work for military requirements and the results of experimental and theoretical work shall be published or otherwise made generally available". This achievement has been brought about through the initiative of Unesco, which, at its general conference in Florence in 1950, instructed its director-general "To assist and encourage the formation and organization of regional research centres and laboratories in order to increase and make more fruitful the international co-operation of scientists in search for new knowledge in fields where the effort of any one country in the region is insufficient for the task".

During an initial survey, the particular need appeared for joint action in nuclear research among European countries, for the modern equipment required is often very costly. Although work with cosmic rays is relatively inexpensive to carry out and is extremely fruitful in results, its role is to make a preliminary survey of the high-energy field. Many important findings which are made by it can only be followed up if high intensities of high-energy particles are available. These high intensities can be produced in a perfectly controllable manner with modern high-energy particle accelerators, but these are extremely costly and may be quite beyond the resources of many countries.

The European Council for Nuclear Research (C.E.R.N.) was therefore established in May 1952, to work out plans for co-operation in this field. One of the Council's first acts was to arrange an international scientific conference in Copenhagen during June 1952. Many eminent nuclear physicists were present, including a number working in the field of cosmic rays. The state of knowledge at that date was examined in order to obtain guidance upon the main problems requiring further investigation. After the conference, four study-groups were set up by the Council. The first was to consider the design of a 600-MeV. synchrocyclotron, the second the design of a proton synchrotron for energies greater than 10 GeV., the third was to concern itself with theoretical studies of interest to the Council and the promotion of other forms of co-operation in nuclear physics, and the fourth was to work out plans for a laboratory.

The 600-MeV. synchrocyclotron was chosen because as a machine it is relatively straightforward to design and build, and yet when completed it will provide a laboratory source of mesons and high-energy protons for European physicists who have not had previous access to them. It should be practical to complete this machine in a few years, and much in advance of the time likely to be required to build the proton synchrotron. In the course of its development it will provide experience in running a co-operative research programme with a project the technical problems of which are relatively straightforward. When it is completed, physicists will, in the course of its use, become familiar with the techniques necessary when working with high-energy particles, and so should be ready to make full use of the big machine with the minimum of delay when it is completed.

The proton synchrotron is in an entirely different category, for an energy greater than 10 GeV. is well beyond that of the biggest machine now being built in the United States, and so when completed it should make available new fields of work only investigated previously by workers with cosmic rays.

The basic programme now envisaged for the Organization is the construction and organization of an international laboratory for research on high-energy particles, including work on cosmic rays, and the organization and sponsoring of international co-operation in nuclear research including co-operation outside the laboratory.

The laboratory will be located at Geneva, Switzerland, on ground offered by the Government of that Canton. The site is approximately 600 metres square and adjoins French territory about three miles north-west of the town. The main tools of the laboratory will be the two high-energy particle accelerators which have been studied.

The design of the synchrocyclotron is already well advanced, and its construction can be started quickly once the Organization is established. The machine will be used for neutron and proton studies up to 600 MeV., meson studies up to 300 MeV., radiochemistry, and possibly production of more than one π meson in some nuclear collisions. The cyclotron magnet will have a pole diameter of 5 metres and will weigh 2,500 tons. It will be excited by two coils weighing 180 tons with a power consumption of 700 kW. to give a magnetic field at the centre of 20,500 oersteds. Between the poles will be mounted a stainless-steel vacuum chamber containing the accelerating electrodes. The machine is primarily designed to accelerate protons; but provision will probably also be made for the acceleration of deuterons and α-particles. For protons, the radio-frequency at the start of the acceleration will be 31 Mc./s. and the frequency change required will be 2 to 1. The frequency repetition-rate will be 50 cycles per second. Considerable attention has been given to the experimental facilities to be provided with this machine. Collimated beams of protons, neutrons and mesons will be available. There will be one experimental room for neutron and π-meson studies. Neutrons of energies up to 600 MeV. will be available at an

estimated flux of approximately 10^5/cm.^{2}/sec., and the energy of the π-mesons will be up to 350 MeV. with an estimated flux of 10^3/cm.^{2}/sec. In a second experimental room, the extracted proton beam will be available with a maximum energy of approximately 550 MeV. and a flux of 10^7/cm.^{2}/sec.; π^+ mesons will also be available in this room up to an energy of about 200 MeV., again with a flux of approximately 10^2/cm.^{2}/sec. Thick shielding walls will separate both experimental rooms from the cyclotron.

Plans for the proton synchrotron are not so far advanced. The target energy for it has been set at not less than 10 GeV.; but it seems from the design study that 20 GeV. or higher will be achieved. Confidence that a proton synchrotron for this energy region can be built has been obtained from the success with which other large proton synchrotrons such as the Brookhaven cosmotron have been operated, as well as from the design study which has been in progress for the past year. This study was upon a machine to use the alternating-gradient focusing principle announced by Courant, Livingston and Snyder in 1952 [1]. In any synchrotron the particles being accelerated perform vertical and radial oscillations within the annular vacuum chamber. The amplitude of these oscillations determines the required cross-section of the annulus and hence the size and cost of the magnet providing the guiding and focusing field. With a conventional machine, this magnetic field is made to fall off approximately linearly with radius, so that $\frac{\partial H}{\partial r} = -n\frac{H_0}{r_0}$, where n is a constant such that $0 < n < 1$, H is the field at radius r, and H_0 is the field at the particular radius r_0. When the condition $0 < n < 1$ holds, the particles being accelerated are acted upon by relatively weak focusing forces in both vertical and radial directions. In an alternating-gradient focusing machine, it is proposed to construct the magnet in a number of sectors and to make $|n| \gg 1$ with positive and negative values in alternate sectors. The forces acting upon the particles will then be strongly defocusing in the radial direction and strongly focusing in the vertical direction for sectors with positive values of n and vice versa. Courant *et al.* showed that the net effect upon particles passing around a machine constructed in this way would be a strong focusing action in both directions. This offered the possibility of achieving a reduction in both the vertical and radial dimensions of the aperture simultaneously.

The new principle has required a very careful design study, for as well as its important advantage, it also has inherent in it certain definite limitations which have had to be understood, and which will have to be taken into account in designing the machine. The limitations arise from the fact that the strongly focused particles are made to perform oscillations of small wave-length. These oscillations are very sensitive to small irregularities in the magnetic field whether they are due to mechanical or electrical causes, and consequently dangerous resonances can occur. The design study has had to take into account the practical considerations of achievable accuracies in constructing various parts of the machine, and determine how much advantage can be taken of the alternating-gradient focusing principle, that is, what should be the value of n. The relative importance of variations in each of the main design parameters has been worked out, and several possible designs obtained for machines of 30 GeV. energy with apertures less than $\pm$ 10 cm. and n's in the region of 100–1,000. A magnet weight of less than 10,000 tons seems practical with a manufacturing tolerance on the position of the equilibrium orbit of 0·020 in. However, more information is required upon the mechanical and magnetic tolerances achievable in the manufacture and measurement of magnets with various values of n and different apertures before a final choice of parameters can be made. Investigations are being carried out to obtain this information. Other problems in connexion with the machine, such as the design of the radio-frequency system and of the injector, are also being studied. It will be one of the major tasks of the new laboratory in its initial stages to complete this study and, with the help of industry, carry through its development and construction. It is estimated it will take six years to build, requiring a total staff of about a hundred scientists, draughtsmen and technicians, and will cost approximately 55 million Swiss francs. The plans for this machine envisage it being installed in a trench-type building below ground, with a thick roof over the trench to provide protection for the staff and reduce radiation in the main laboratory buildings to an acceptable level.

To make full use of the possibilities offered by these two accelerators, it will be necessary to gather together staff with specialist knowledge in several different fields. The present plans envisage a strong theoretical group which will work in Copenhagen for some time to come. It will carry out fundamental studies and take part in the planning and interpretation of the experimental work. A chemical department will be required for radiochemistry and to provide any analytical techniques required; and specialists in electronics and instrumentation for the design of experimental apparatus, and a central drawing office and workshop, will be necessary, in addition to the staff of nuclear physicists.

The architectural planning of the laboratory is well advanced. The main features of the accelerator buildings are entirely determined by their physical characteristics and functional requirements. For the laboratory it is proposed to construct single-story buildings with basements, which should allow great flexibility in detail, facilitate movements between laboratories and reduce radiation interference between different experimental installations. A unit method of construction is to be adopted, and careful attention has been given to the mode of distribution of services and the method of construction of partition walls to allow great flexibility in the internal arrangements. Present plans are for a main building with a total floor area of about 5,000 sq. m. available for the use of the scientific and technical staff; 2,500 sq. m. for lecture rooms, restaurant and administration, and a main workshop of 1,000 sq. m. floor area.

The construction of all the buildings and the arrangements of the site are expected to take three years and to cost about 23 million Swiss francs. The cost of all the activities, including construction and installation, during the first seven years is estimated at 120 million Swiss francs. The funds will be provided by the member States on a relative scale based on their average net national incomes; but no one State will pay more than 25 per cent of the total.

D. W. Fry

[1] Courant, E. D., Livingston, N. S., and Snyder, H. S., *Phys. Rev.*, **88**. 1190 (1952).

CYBERNETICS

DURING the recent meeting in Liverpool of the British Association, a joint symposium was formed by Sections J (Psychology), A (Physics) and I (Physiology), under the general title of "Cybernetics". Under the chairmanship of Prof. Ross Ashby, three papers were read and discussed: "Organisms and Mechanisms — an Introductory Survey" (Dr. Colin Cherry), "The Impact of Information Theory on Psychology" (Dr. W. E. Hick), and "On Comparing the Brain with Machines" (Dr. D. M. MacKay).

In his introductory paper, Dr. Cherry referred to the origin of the word "La Cybèrnétique" as being due to André Ampère who, in his attempted classification of human knowledge (1834), defined the concept as 'the science of government', taking the word from κυβερνητης, meaning 'a steersman'. Government, whether it means the administration of a country, or the control of our own personal actions, bears some analogy to the steering of a ship. It implies a stabilized directing on to a definite course, or goal-directed activity. Our modern concern with cybernetics represents, Dr. Cherry stressed, a revival of an intense interest of the seventeenth- and eighteenth-century philosophers, namely, the comparison of machines, human beings and social bodies —but with some essential differences. Descartes, who was a focus of such interest, argued in extremely vague philosophical terms; nowadays we are using mathematical analysis and, furthermore, we have techniques for constructing actual machines. Some machines show action which simulates closely certain aspects of human behaviour, mental and physical. How far may such machines go, if only in principle, and what is the purpose of such mechanistic description?

Popular language suggests we readily lean towards mechanistic analogies; we speak of 'the man at the helm', or again, of a man 'running off the rails'. But such metaphors do not form true scientific statements. Our modern interest, however, is not a simple return to the mechanistic–vitalistic (man or machine?) controversy of Cartesian dualism—not in philosophy so much as in physics. Questions such as 'Can a machine think?' are more profitably interpreted as 'What aspects of psychology may validly be discussed in the language of mathematics and physics?' (for example, 'thinking', 'learning', 'recognizing'?).

Modern machines which have self-stabilizing or goal-directed action and which show some similarity to human behaviour are plentiful, and a great body of mathematical analysis has been constructed. These machines are conveniently divided into two classes, exhibiting respectively body-like and mind-like behaviour. The former includes the so-called servo-mechanisms or automatic controls, and the latter relates to computing machines, the so-called 'electronic brains' (though if such science fiction images are necessary, 'electronic brain-extensions' may be preferable).

One idea which runs like a thread through the pattern of relevant studies is the idea of 'information'; information circulates through servo-mechanisms, calculating machines, and all communication channels, and again in the nervous system; it is manifest in human social institutions and systems. But 'information', like 'language', is a many-sided concept; Dr. Cherry directed attention to three aspects, each of which is concerned in the relation of cybernetics to psychology. First, and most important, selective-information refers to the correct selection of signal-elements or signs from a given set (letters, words or other signs, purely at syntactic level, but without regard to their designata); this is the concern of statistical communication theory (and, in a broader sense, of information theory), which sets up a precise measure of selective-information content of messages in terms of the statistical rarity of the signals or signs. Secondly, there is the semantic information which emerges in some cases (involving humans), where the signals are regarded as 'meaningful'. Finally, there are the pragmatic aspects, or those aspects of messages which convey information to a specific recipient and which affect his personal response. Dr. Cherry ended with a brief description of the measure of selective-information content, and sounded warnings of the pitfalls which surround anyone who attempts to 'apply' information theory outside its legitimate sphere.

The second speaker, Dr. W. E. Hick, illustrated a number of ways in which some of the concepts of this theory may be employed, quite legitimately, in practical psychological studies. From this point of view the organism is regarded as a 'black box' to which stimuli are applied, and the responses of which are observed. The 'black box' is here regarded as if it were performing the dual role of communication channel and code-changing transducer—*as if* the organism were a channel along which information flows. From this point of view, a natural descriptive system for those aspects of behaviour which may be described statistically is provided by information theory.

Very broadly, such analysis has been applied in three fields of experimental psychology: (1) hearing, language and speech; (2) reaction times; (3) learning.

Dr. Hick referred to the value of having a precise theory and measure of information when working in these various fields; descriptive or qualitative results may then be made quantitative, construction of experiments may be suggested, and their results may more readily be interpreted.

It is essentially the selective aspect of information which is concerned here, and not the semantic or pragmatic. This may seem strange, in a psychological context, but is a logical consequence of the 'black-box' point of view of regarding the organism as if it were a communication channel. But it must also be remembered that it is only this selective aspect which has as yet been based on a solid foundation of mathematics, and it is only the selective-information content of signals which may be measured quantitatively.

Illustrations were given by Dr. Hick from these three fields of experimental psychology, showing how a human 'black-box' behaves, in comparison to a communication channel—inasmuch as an information theory description may be applied to both. For example, in the first field, the stimuli (or 'messages') applied to the input of the 'black-box' may be spoken words, as in studies of speech recognition. In the second, the stimuli may be represented by successive selections of visual signals from a simple alphabet of signals, to which the subject is required to respond in some prearranged manner; then the relation between the subject's times of response and the errors he makes is shown to bear direct analogy to the properties of a simple communication channel—

in terms of the established measure of selective information-rate. The interpretation of such experiments, and others of like kind, is that, under a considerable variety of error-making conditions, the rate of selective-information in the human 'black-box' channel remains substantially constant. Dr. Hick gave a number of illustrations of such experiments, involving stimuli and responses of several different forms, and of extensions of the method to apply to an alphabet of signal-stimuli having unequal (objective) probabilities of occurring. He afterwards discussed these experiments, and their interpretations by the selective-information-content measure, in relation to other studies of reactions, emphasizing at the same time that the common idea of 'reaction-time' as a kind of constant, so frequently employed in tests for drivers and air pilots, is grossly inadequate. Dr. Hick ended his lecture by emphasizing that his experiments consisted purely of observations of behaviour and that, where probabilities were mentioned, they were objective, relative frequencies; nevertheless, he suggested, information theory has further value for psychology in that it provides a number of general concepts and terms which may aid discussion, at the purely subjective levels—though care must be taken to distinguish such subjective inquiry from direct, quantitative applications of information theory to behavioural psychology.

The last speaker, Dr. D. M. MacKay, distinguished three different ways in which brains are often compared with machines, for three different purposes. The first is the popular comparison between brains and existing machines, notably electronic digital computers. It is a relevant comment that such machines are deliberately designed not to imitate the brain in most of its more characteristic functions; on the contrary, they may be said to take over some of the more machine-like functions of the mind. The second concerns the question as to whether we can ever design an artefact ('artificial mechanism') to imitate any specified aspect of human behaviour; for example, to frame novel hypotheses or (notoriously) to write sonnets.

But the third manner of brain/machine comparison to which Dr. MacKay referred really formed his main theme: Can we build a model working internally on the same principles as the brain? Such may not be an actual engineered machine, but a conceptual model, conforming to all conditions demanded by present knowledge, broad though they be, and having as its purpose the setting up of a description not in the distinct languages of psychiatry, or physiology, or anatomy, but in language common to all these; to provide working links between these various fields. The language of information and control theory promises to be of value in this move toward unification of concepts because, in a sense, it belongs to both the psychology field and the domain of direct physical observation (physics, physiology . . . 'mechanism'). The theoretical characteristics of such a model may then be checked against observation of the brain in action, the discrepancies yielding information towards refining or replacing the model; and so repeatedly, by the usual inductive–deductive procedure. It is important that such models, or descriptions, should not only 'work' in the manner of a normal brain, and meet all functional tests in a similar way, but also that they should 'go wrong' likewise—though Dr. MacKay stressed that this is very different from naïvely attributing mental illness to electronic computing machines that break down.

A further requirement of the model is that, like the brain, it must have been capable of 'growing that way'; such consideration has led to investigations of the possibilities of self-organizing statistical models—models in which the various elements not only are interconnected more or less randomly, but which also themselves function indeterministically to some controllable extent. Such a model should be capable of adjusting the rules of its activity according to the degree of success it attains, by adjusting the relative probabilities of different patterns of activity. Dr. MacKay elaborated upon such a model, describing how, given some positive indication of success or failure, it could continually improve its 'goal-seeking' activity, and "grope its way more and more quickly into a pattern of activity to 'match' any incoming patterns that persisted in occurring".

Finally, Dr. MacKay dealt with questions of purpose. Such theoretical models are intended, he stressed, as research tools. They represent a method of describing 'the thinking process' in disciplined language, suitably objective as to assist the physiologist, yet not divorced from psychiatric reality, so as to permit further assistance in diagnosis, study and treatment of mental illness.

Such work is so often misinterpreted as an attempt to depose man from his special position; man would be 'nothing but' a machine, we often hear, if the brain is described in physical terms. The fault with such reductionist argument, as Dr. MacKay stressed, lies not in the possible incompleteness of the description, but in confusion between two distinct language-systems. Models of the brain form descriptions in observer-language—a set of directions by which, for example, replicas can be made; but a man's personal experience, or rather his statements about his experience, are in actor-language. Questions of personal decision-making, or questions of responsibility, simply do not form part of the brain-model because they cannot be framed in observer-language. However great our understanding of brain structure and functioning, however accurate the model, we none of us are one jot relieved from responsibility for our actions.

The discussion which followed centred mainly around the different uses of the words 'model', 'artefact', or 'mechanism' in such contexts. In response to one speaker who asked if real working models had actually yet been made, Prof. Ross Ashby gave a brief account of his 'homeostat' model, and of its behaviour.

E. Colin Cherry

UTILIZATION OF DIGITAL COMPUTING MACHINES

At the recent meeting in Liverpool of the British Association, Section G (Engineering) held a symposium on the utilization of digital computing machines in engineering and industry. Prof. F. C. Williams, of the University of Manchester, opened the meeting. Before introducing the main speakers, he said that the object of the session was to strip the 'electronic brain' of some of its glamour and to present it to engineers in its everyday shape, which is that of a potentially powerful new tool to aid the solution of engineering design problems. Although at present this tool is in an early stage of development, it is none the less already capable of revolutionizing design procedures—for example, by the rapid

analysis of a large number of trial designs of turbine shafts or steel frameworks.

Dealing with the machine at the University of Manchester, Prof. Williams said that it originated from the joint initiative of himself and Prof. M. H. A. Newman, of the Mathematics Department. Although the machine was originally built to gain experience in design techniques, it soon became apparent that it is capable of handling a volume of work far in excess of the University's needs, and for this reason it was made available to other universities and to industry. This use of the machine by outside organizations has increased rapidly and, what is perhaps more important, those organizations which have started to use the machine have found themselves calling upon its services to an increasing extent as their experience of its potentialities increases. The University does not undertake the solution of problems, but instead trains representatives of other organizations in the use of the machine and afterwards makes the machine available to them. The period of training is about two or three months.

On the question of reliability, Prof. Williams said that, at the present stage of development, machines are serviceable for about 80 per cent of the time, and this is quite sufficient to enable them to be used as the basis of a computing service run on business lines. As in the case of human computers working with desk machines, electronic machines are liable to make transient mistakes, and results should be checked, also with the machine, in the usual way. However, because of the high speed of the machine, a fault-free run of several minutes corresponds to less than one mistake per week by a human computer. Finally, Prof. Williams stressed the ease with which digital machines can be switched from one problem to another. It simply requires a new set of instructions, which can be 'fed' into the machine from punched tape or cards in a few seconds.

Prof. Williams then introduced the other speakers : Mr. R. K. Livesley, of the Computing Machine Laboratory, University of Manchester, and Mr. G. G. Alway, of the Mathematics Division of the National Physical Laboratory, Teddington.

Mr. Livesley described first the general principles on which electronic digital computers are based. The most important fact about these machines, he said, is that they carry out calculations according to a pre-arranged sequence of coded instructions. Once this sequence of instructions (known as the 'programme') has been prepared, the computer carries out the calculations automatically. It is the job of the machine user to prepare the programme for his particular problem, and this means that he has first to decide in detail the sequence of arithmetic operations to be performed, and then translate this scheme into language understood by the machine.

It was emphasized by Mr. Livesley that, once the programme has been perfected, it can be used unchanged for different sets of numerical data. Thus a programme is very similar to a mass-production jig—both are capital investments which can be used an unlimited number of times. Like the machine tool to which the jig is attached, an electronic computer is most productive when engaged on repetition work—it is seldom worth while making either a jig or a programme if it is to be used only once. Such repetition work is very common in engineering calculations. Most of the numerical work associated with designing is concerned with the analysis of alternative layouts, the only difference in the calculations being the actual numbers occurring.

To illustrate the use of digital computers in design work, Mr. Livesley described four programmes developed for use with the Manchester computer. These cover the calculation of the natural frequencies of shaft systems in torsional and in lateral vibration, the design of certain types of cam, and the analysis of rigid-framed building structures. He said that the existence of these programmes means that certain common calculations can be carried out with scarcely any effort beyond that of feeding the initial data into the computer. On the Manchester machine it has been found that the speed factor over hand computation is often of the order of 150 : 1—an ample repayment for initial time spent on programming.

Mr. Livesley defined the ideal programme as one which carries out all the calculations of a problem, from the data on the designer's drawing-board to the final facts he wants to know, and which is sufficiently flexible to cover all problems of a given type. The first requirement helps to cut down possibility of error, while the second avoids the necessity of developing new programmes for very similar work. One usually finds that the human beings preparing data for a machine are far more prone to error than the machine itself, and consequently it is essential to make the input of data as simple as possible, getting the machine to do the easy parts of the calculation as well as the most difficult. The advent of computers, and the demand for flexibility in programmes, has led to interesting developments in numerical analysis. New methods, especially suited to automatic machines, have shown definite superiority when compared with methods generally in use on desk calculating machines.

At the present time, continued Mr. Livesley, there is a lack of programmes and programmers rather than of computing machines. It is only as programmes are developed for standard calculations that the existing machines can be fully used. The training time for a programmer is from three to twelve weeks, with a similar period for the time usually required to develop a programme for a given calculation. Mr. Livesley concluded by emphasizing that the efficient use of a computing machine depends entirely on the programmer.

The subject of Mr. Alway's paper was the application of the ACE, the machine at the National Physical Laboratory, Teddington, to aircraft design problems. Supplementing some remarks of Prof. Williams, Mr. Alway said that the ACE group also instructs people in the use of their machine, and, in addition, a large team of programmers enables them to undertake work directly. The pilot model of the ACE has been in operation for eighteen months, and during this time a considerable library of programmes has been built up. The machine has only a limited high-speed store; but the use of Hollerith punched cards as an auxiliary store has been very successful. Certain features of the logical design of the machine enable calculations to be done while cards are being read or punched. By this means the disparity between the speeds of operation of the auxiliary store and the working store is largely overcome.

The pilot model has been very successful in dealing with problems of matrix arithmetic. Programmes for solving sets of linear simultaneous equations have been made using the card store already described.

These can solve sets involving up to 192 unknowns and can invert matrices of orders up to 95. Programmes have also been made for finding the latent roots and vectors of matrices. A fast programme, in which all the numbers concerned are kept in the high-speed store, can deal with symmetric matrices of order 19 and unsymmetric matrices of order 15. For matrices of higher orders, punched cards are used as an auxiliary store. Similar programmes exist for dealing with complex latent roots. All these programmes are in constant use, and many applications have been made to problems arising in aircraft design.

Mr. Alway then described a typical problem of aerodynamic design, namely, the flutter problem. Flutter is the condition where the aerodynamic forces tend to reinforce the elastic forces in a vibrating wing, and the aeroplane must be designed so that this will not occur at any speed at which it is supposed to fly. The differential equations representing the complete motion of the whole aircraft as an elastic body subject to aerodynamic forces are intractable, but design engineers are helped if, as a first approximation, the modes of vibration of the aeroplane *in vacuo* are obtained. This involves finding the latent roots and vectors of a matrix. For the complete flutter problem the equations can be set up for a limited number of degrees of freedom, and their solution amounts to finding values of velocity and frequency which make a certain determinant zero. Each element of this determinant is of the form $a\omega^2 + ib\omega + c + e/V^2 + id$, where ω is the frequency, V the aircraft velocity, and a, b and c to some extent depend on ω. One programme for dealing with this part of the flutter problem is arranged so that the complex determinant is evaluated for pairs of values of ω and V, and the values of ω and V which make the determinant zero are then found by interpolation. The computation time for a single determinant of order 8, corresponding to 8 degrees of freedom, is a quarter of a minute.

In conclusion, Mr. Alway pointed out that, unlike analogue simulators, an automatic digital computer becomes more powerful as more programmes are developed and existing techniques stream-lined.

THE PHARMACIST AND THERAPEUTICS

THE British Pharmaceutical Conference, held during August 31–September 4, looked back through ninety years to its foundation in 1863, and its chairman this year, Dr. G. R. Boyes, contributed to it a valuable address entitled "The Pharmacist and Therapeutics". Three years before the long series of these conferences began, Oliver Wendell Holmes stated his belief that, if the whole of the materia medica then in use in the United States could have been sunk to the bottom of the sea, it would have been "all the better for mankind and all the worse for the fishes"; and Dr. Boyes considers that these words could have been applied also to the British materia medica of that day. The publication of the first British Pharmacopœia was a major step towards the improvement of British pharmacy, and the records of successive British Pharmaceutical Conferences show how much the pharmacists have contributed to the subsequent improvement in the methods of preparation, formulation and analytical control of substances used for the treatment and control of disease. Dr. Boyes, in his address, reviewed some of the many important contributions made by pharmacy to the materia medica of to-day.

The primary functions of a pharmacist are to provide the drugs and preparations of drugs needed by medical men, to see that these are pure and active and that they are supplied in forms suitable for the various methods of administration of them. The pharmacist thus bears a great responsibility and must have a thorough knowledge of the chemistry and physics of drugs, of analytical methods used for their assay and of the principles of drug formulation. He needs also a knowledge of physiology and pharmacology. The 'chemist', in other words, from whom we buy our pills and potions is highly skilled in his job and is carefully trained for it. He has, however, fewer opportunities nowadays to exercise his skill in the art of compounding medicines, and more and more is he asked to supply medicaments which reach him ready for use.

Outstanding features of modern pharmacy are the extensive use of synthetic substances and the decline in the use of crude preparations, for which isolated substances active in them have been substituted. Synthetic substances were introduced as long ago as 1896; but their use has greatly increased during the past ten or twenty years, and Dr. Boyes quoted figures which indicate the astonishing growth and magnitude of the industry now engaged in the manufacture of these synthetic substances and isolated active principles. He rightly emphasized the value of the contributions made by pharmacy to this remarkable development.

The discovery of a new drug, whether it is used by medical men or veterinarians, is seldom due to chance. It is usually the result of long periods of co-ordinated research, the testing of scores or hundreds of synthetic compounds, and the choice, as a result of all this work, of a few substances which promise to give the required balance between efficacy, ease of administration and a minimum of cost and of toxicity to the patient. The public are seldom fully aware of the amount of work of this kind involved, or of the degree of skill, experience and training needed for it. As Dr. Boyes says, work of this kind has developed for us a variety of drugs in use to-day, among which are the derivatives of barbituric acid, synthetic œstrogens and other sex hormones, sulphonamides, antimalarial drugs and drugs which reduce pain or induce anæsthesia.

At the same time, drugs derived from plants and animals have not been neglected. Dr. Boyes tells us of the work done on some of these. Among the plant-products are khellin, quinine, digitalis and morphine. The laboratory synthesis of morphine has recently been accomplished—a feat which only the chemist can rightly assess. Other plant-products are penicillin, streptomycin, aureomycin and the other antibiotics, to which new ones are constantly being added. Among animal products are the various hormones, the substances used for blood-transfusions and antitoxins. Dr. Boyes gave special attention to the work on corticotrophin, insulin and the recent isolation by chromatographic methods from raw liver of cyanocobalamin, which is also produced by *Streptomyces griseus*, the organism which yields streptomycin.

The remainder of Dr. Boyes's address was devoted to sections on the analytical control of drugs and to their biological and clinical trials. This part of

the address showed clearly that, when a therapeutic substance has been discovered or synthesized, a great deal more remains to be done before it can be released for use. It is necessary to make sure that its pharmacological and therapeutic activities do not vary from batch to batch of the manufactured product. The biological activity of drugs which cannot, for various reasons, be made in a chemically pure state must be controlled by biological tests on animals; and carefully planned and rigidly controlled clinical trials on human patients are done whenever these are possible. Nor must we forget the considerable work required to ensure that the drug is issued in a form in which it shows its characteristic properties, that it is safe and convenient to use and that it remains stable for a reasonable time under the climatic conditions to which it is to be subjected. This task, known as the formulation of medical substances, is the responsibility of the pharmacist.

Discussing the international aspects of drug-production, Dr. Boyes commented on the growing need for close international collaboration between the pharmacists of all nations and indicated the progress made in this respect. The publication by the World Health Organization of an International Pharmacopœia should help to extend international agreement on standards for drugs and pharmaceutical preparations.

In conclusion, Dr. Boyes discussed the responsibilities of the pharmacist and claimed that modern pharmacy should be, not the handmaid of medicine, but its co-partner with equal responsibilities. His address will evoke much sympathy with this view. Some readers of it will wonder, however, why it does not consider the needs and work of the modern veterinarian, who is, to an ever-increasing degree, collaborating with, and making important contributions to, human medicine. A future which gave us the medical man, the veterinary surgeon and the pharmacist as equal partners in a humanitarian team would indeed be worth living to see. There is much evidence that it will, in fact, be the heritage of a generation not very far removed from the one to which Dr. Boyes belongs. G. Lapage

A NEW FOSSIL MAN FROM SOUTH AFRICA

By Dr. J. C. TREVOR

Department of Archæology and Anthropology, University of Cambridge

In January 1953, Mr. Keith Jolly, an archæologist, recovered the major portion of a human calotte from the surface of a wind-eroded site about midway between the village of Hopefield in the Cape Province and the southernmost extension of Saldanha Bay. Only brief preliminary accounts of the Hopefield site and 'Saldanha Man' by A. J. H. Goodwin (*S. Afric. Archæol. Bull.*, No. 30, 41, Claremont, Cape Town; 5*s.*) and Prof. M. R. Drennan (*S. Afric. J. Sci.*, 50, 7 (1953); *Illust. Lond. News*, No. 5971, 480 (Sept. 26, 1953), 2*s.*) have so far appeared, and even since these were written additional information relating to the discovery has become available. Curiously enough, C. P. Thunberg (1743–1828), who was to succeed Linnæus at Uppsala in 1784, had in his thirtieth year visited the farm Elandsfontein, on which most of the site lies, and he later described its flora and fauna. The fossiliferous nature of the Elandsfontein deposits, however, did not become apparent until shortly after the Second World War, and credit for ensuring that their possibilities were not neglected must be given to a small committee formed under the chairmanship of Prof. Drennan at the University of Cape Town.

A rare giraffid (*Griquatherium*) occurs among the fossil mammals, of which the extinct forms are represented most abundantly by the Cape horse and the living forms by several genera of the commoner African antelopes. The fluorine content of the remains of a selected series of the extinct animals, including the giant wart-hog *Mesochoerus*, and that of the human skull-vault, were recently determined in London by C. F. M. Fryd, of the Government Chemist's Department, and there is a remarkable agreement between them. Because of the high rate of fluorination at the site, Dr. K. P. Oakley, of the British Museum (Natural History), who recently inspected it, considers that their geological ages are, within narrow limits, identical. On the basis of faunal and archæological correlations elsewhere in the Union, he also tentatively supposes that the man of Hopefield should be associated with the Late Acheulean or Fauresmith hand-axes, characteristic of the South African Earlier Stone Age, rather than with the Still Bay points, which typify the Middle Stone Age. Artefacts belonging to both cultures are found on the site; but those of the Still Bay indicate only its earlier or typical phases. No trace of the use of fire has yet been observed.

The human bones, which are being studied by Prof. Drennan, comprise the frontal, both parietals, and the occipital of a young adult subject whose probable sex is regarded as male. Their owner was manifestly different from any normal member of the species *Homo sapiens*, and what is preserved of him bears a strong resemblance to the cranium from the Broken Hill Mine in Northern Rhodesia, accidentally brought to light on June 17, 1921, and now at South Kensington. The most detailed examination of the Rhodesian skull is that made by Dr. G. M. Morant (*Ann. Eugen.*, 3, 337; 1928), who concluded that, although more closely related to certain Neandertaloid types than to modern man, it could be clearly distinguished from both. A striking feature shared by the Hopefield and Broken Hill specimens is the lateral massiveness of the torus, or bony bar, above the orbits—not so pronounced in the Hopefield calotte, of which almost the entire missing left brow-ridge has lately been retrieved—but Prof. Drennan is also impressed with the apparent affinities of the new African find to the far-removed ancient Ngandong hominids of central Java. The results of his investigation will be eagerly awaited in view of the importance they are bound to have for the advancement of knowledge in the field of human palæontology.

OBITUARIES

Sir Thomas Taylor, C.B.E.

The sudden death on August 29 of Sir Thomas Taylor will be mourned by members of universities and allied bodies throughout the world. Widely known, loved and respected, his untimely death at the age of fifty-eight will come as a cruel blow.

Fellow and former Scholar of Brasenose College and a Rhodes Travelling Fellow, he taught and made distinguished contributions to chemistry, notably stereochemistry. His name is connected with two standard works, the English revision of "Richter", the second volume of which he edited, and Sidgwick's "Organic Chemistry of Nitrogen", which he revised in conjunction with Prof. Wilson Baker.

He served with distinction in the two World Wars, and in the second played a major part in the organization of the British Commonwealth Scientific Office in Washington, as well as serving as scientific adviser to the Supreme Allied Commander, South-East Asia. Afterwards, he became principal of the University College of the West Indies, in Jamaica, and in 1952, of the University College of the South-West, Exeter. It is fitting that his services were recognized by the award of the C.B.E., and later, of a knighthood.

A mere catalogue of Sir Thomas Taylor's distinguished career and singular range of achievements, however, would form an inadequate tribute, for he was a man of many parts, an impressive scholar, gifted with an acute and agile mind, which, coupled with vision and prodigious energy, marked him as an outstanding university administrator. He was a man of paradoxes as well as of parts. A vivid personality, yet modest; disconcertingly direct, yet kind; a man with clear-cut likes and dislikes, yet deploring alike fulsome praise and harsh criticism. He was a scholar with a zest for living and had a rich human understanding, with a pervasive sense of humour. Cultured, widely travelled, with a rich store of anecdote, aided by a remarkable memory, to receive his hospitality, and to listen to his witty, well-informed conversation, was an engaging and stimulating experience.

Of his many achievements, both in his beloved Oxford and elsewhere, none can be judged greater than his leading part in the creation of the University College of the West Indies, in the form envisaged in the Irvine Report. His discharge of the duties of first principal was masterly, and won for him universal respect and admiration. All who served with him have reason to remember his wisdom, guidance and example with enduring gratitude. He faced unflinchingly the unending succession of stern tasks inevitable in the creation of a new institution of this character, and owing to his unfailing wisdom, leadership and immense drive, they were accomplished. When, in 1951, all seemed to have gone so well, the young and growing college was seared by a devastating hurricane at a most critical time. It was his courage, determination and buoyancy of spirit that did so much to allay discouragement and to re-invigorate all efforts. Despite the pressure and burden of administration, he spared no pains to come to know every member of his staff and all undergraduates, and his sympathetic guidance was always freely given.

The universities and colleges Sir William served were not alone in receiving the benefits of his scholarly gifts and administrative experience, for they were given unstintingly in the wider sphere of higher education within the British Commonwealth, and societies fostering cultural activities in many forms received his valued support, together with that of Lady Taylor. Musicians, naturalists and bird lovers with unbounded enthusiasm, their combined activities have enriched the annals of such organizations in many parts of the world.

His passing will be deeply felt by friends scattered throughout the world. To Lady Taylor, who survives him, we offer our deepest sympathy.

NORMAN MILLOTT

Prof. E. C. Jeffrey

EDWARD CHARLES JEFFREY, professor of plant morphology at Harvard University, died on April 19, 1952, in his eighty-sixth year. A Canadian by birth, and a graduate of the University of Toronto, he received a doctorate from Harvard University in 1898, and in 1902 was made a member of its Faculty. His position in the field of botanical research is attested by a list of 115 publications, and his success as a teacher is evidenced by some thirty graduate students trained under his direction and well represented among active American botanists.

Prof. Jeffrey was one of that small band of British post-Darwinian plant morphologists including Scott, Bower, Worsdell and Gwynn-Vaughan which, at the beginning of the century, set itself to reconstruct the evolutionary history of vascular plants. At the very outset of his studies, Jeffrey took up the stelar theory of van Tieghem and established it on a sound foundation. Then he began a search for valid evolutionary criteria applicable to the vegetative parts of vascular plants. He utilized the current biological doctrines of retention, reversion and recapitulation in an attempt to relegate them to their proper phyletic positions and, above all, he explored the fossil record, which he realized was the final court of appeal in evolutionary problems. He was a pioneer in the work on Mesozoic lignites and, incidentally, he brought the celloidin technique to a point of high precision. From the lignites it was but a step to the study of the microscopy of coal, a subject to which he devoted enormous labour. He advanced a sound anatomical interpretation and ecological explanation for the evolution of angiosperm herbs from woody ancestors. In his later years, he turned to cytogenetics and was a pioneer in the assertion that "the angiosperms are a mass of hybrids", and that an evolutionary theory based upon the cavortings of *Oenothera lamarckiana* was indeed a "mutation myth".

Prof. Jeffrey was a creative genius and a man of strong enthusiasms and convictions. Almost of necessity he became a controversial figure in American botany. He was a Darwinian who lived to see the superb confidence of his predecessors called in question, and their positive ideals supplanted by a mechanistic and negative outlook. Many of his conclusions ran counter to long-established views, and he met the common fate of the iconoclast. The criticisms levelled against him were often unfair and were based upon superficial understanding and wounded vanity. A policy of studied neglect was effectively applied to his work and others reaped where he had sown.

But the tide is turning, and some leading American workers are already aware of the fact that later discoveries have supported Jeffrey's views surprisingly. It is a safe prediction that the future will set his name high on the roll of those who have made permanent contributions to the philosophy of botany. Then the words of his own sturdy faith, so often repeated, will be amply justified: "Good work tells in the end".

RAY E. TORREY

NEWS and VIEWS

Research at the Wellcome Foundation : Dr. J. W. Trevan, F.R.S.

On August 31, Dr. J. W. Trevan retired from his appointments as director of the Wellcome Research Laboratories, Beckenham, and temporary director of research in the Wellcome Foundation, Ltd., the latter post dating from the death of the late Dr. C. H. Kellaway. Dr. Trevan obtained his medical qualification in 1911, and thereafter for some years worked in the Physiology Department of St. Bartholomew's Hospital, London, where he studied renal secretion, respiration, ketosis in diabetes, and the viscosity of the blood. In the First World War he served as pathologist in the Royal Army Medical Corps in the Near East, and returned to England in 1920 to join the staff of the Wellcome Physiological Research Laboratories as pharmacologist. Here his studies covered a wide diversity of subjects, such as local anæsthetics, the chemotherapy of trypanosomiasis, and quinine alkaloids. He became interested in the biological assay of insulin, and soon was keenly aware of the fallacies inherent in the methods then used for this purpose. Being of a mathematical turn of mind, he applied himself to a statistical study of the subject and ultimately evolved the '*LD*50' technique which is now widely used in assessing toxicity. This work was published in the *Proceedings of the Royal Society*, of which Society he was elected a Fellow in 1946. Latterly, his energies have been devoted mainly to administration, and it was under his direction that vast quantities of biological products used by the medical services during the Second World War were prepared. Although now retiring from his administrative appointments, Dr. Trevan, in the capacity of special consultant, is maintaining his connexion with the Wellcome Foundation.

Dr. D. W. Adamson

Dr. D. W. Adamson, who succeeds Dr. Trevan as research director of the Wellcome Foundation, Ltd., and director of the Wellcome Research Laboratories, Beckenham, graduated at Manchester in 1932, proceeded to a Ph.D. under Prof. J. Kenner, and was a demonstrator until 1936. He then went to Magdalen College, Oxford, worked under Sir Robert Robinson for three years and graduated D.Phil. He spent the war years at the Chemical Defence Experimental Station, Porton, becoming the head of a section dealing with the identification of war gases. Towards the end of the War he went to Germany with a temporary commission to work with the Allied scientific intelligence organization. He joined the Wellcome Chemical Research Laboratories in 1945 and, on the retirement of Dr. Sydney Smith and the reorganization of the Wellcome Research Laboratories in 1948, he became head of the Chemical Division under Dr. Trevan, then director of the Beckenham laboratories. Dr. Adamson's own particular interest at the Wellcome laboratories has been centred largely around compounds of the propanolamine and allylamine types. The intensive and extensive chemical work he has carried on over the years has given an extraordinarily fruitful harvest of compounds of pharmacological interest and therapeutic value. Among these are a potent antihistamine, an analgesic for dogs (a species intolerant to morphine), and some spasmolytics used in the treatment of Parkinson's disease and for the inhibition of gastric motility. All this work, in which, of course, Dr. Adamson collaborated with several colleagues, both pharmacological and chemical, has demonstrated his ability to lead teams of workers; his new appointment gives him much wider scope for the organization of research, for which he has shown great aptitude.

University College in Southern Rhodesia

At the invitation of the Inter-University Council for Higher Education in the Colonies, a delegation from the Rhodesias and Nyasaland recently visited London to discuss the plans for a university college in Central Africa (see *Nature*, July 4, p. 1). The delegation was largely representative of the Rhodesian University Inaugural Board, and during its visit it had discussions with the Inter-University Council and with representatives of the University of London. Full agreement in principle was reached regarding the establishment of the university college, and it was also proposed that it should seek to enter into a special relationship with the University of London. After these discussions, the Government has provisionally agreed to make a grant of £1,250,000 from the Colonial Development and Welfare Fund towards the establishment of a university college open to all races at Salisbury, Southern Rhodesia. The grant is subject to certain conditions, regarding particularly the adequacy of the site, the autonomy of the administering body and to provision being made for recurrent expenditure to be met from other sources. Fuller details will be announced when the delegation has returned to Salisbury and has discussed these proposals with the inaugural board and the authorities concerned in Central Africa.

United Kingdom Agricultural Representatives in the United States

The following announcements have been made by the Agricultural Departments of the United Kingdom: Mr. B. A. Cash-Reed, food attaché in Washington, has been appointed attaché for food and agriculture; Mr. Neil Frank McCann has taken up his duties as agricultural adviser (technical) in the United States, and is attached to the United Kingdom Scientific Mission in Washington; Mr. M. Whalley Taylor, deputy agricultural attaché, has returned to the United Kingdom.

Mr. N. F. McCann was a student at the Harper Adams Agricultural College and in 1929 he obtained the B.Sc. degree in agriculture of the University of London. After practical farming experience, he joined the staff of the Cheshire School of Agriculture. In 1939 he was seconded to the Cheshire War Agricultural Executive Committee. Since 1946 he has been county agricultural officer in Nottingham.

Nuffield Gerontological Research Fellowships

The Nuffield Foundation invited applications some time ago for a Nuffield Research Fellowship for research on the scientific aspects of ageing, to be awarded by a selection committee appointed equally by the Royal Society of London and the Foundation. One fellowship of professorial status or alternatively one or more of less senior status was proposed. The Foundation was, however, impressed by the quality of the candidates, and decided to award two fellowships, one of professorial and one of less senior status: in order to meet the additional award the sum which was reserved has been increased from £25,000 to

£51,000 and the following awards have been made. *Nuffield Professorial Research Fellowship in Gerontology:* Dr. P. L. Krohn, reader in endocrinology, University of Birmingham. Dr. Krohn has taken up his appointment, and his programme of research, aimed at "a causal analysis of the process of ageing", includes a study of the interactions of tissues and their environments (chiefly by grafting tissues of animals of one age into animals of another age), and a study of the factors controlling the duration of reproductive life in primates. This appointment is for five years in the first place and is renewable. *Nuffield Gerontological Research Fellowship:* Dr. D. A. Hall, lecturer in medical biochemistry, University of Leeds. Dr. Hall will take up his fellowship on January 1, 1954. He proposes to study the changes in connective tissue associated with ageing. This appointment is for three years in the first instance.

Vacation Course in Synoptic Meteorology

Since 1950, when the pioneer course was held, the Royal Meteorological Society, in conjunction with the Council for the Promotion of Field Studies, has held a vacation course in elementary synoptic meteorology yearly at the Council's field-centre at Malham Tarn. The fourth such course took place this year during September 9–16 and was attended by some thirty students. There was the usual wide cross-section of ages and occupations. The instructors were Mr. James Paton (director of the course), Scottish secretary of the Royal Meteorological Society and senior lecturer in meteorological physics at the University of Edinburgh, and Mr. C. D. Ovey, a vice-president of the Royal Meteorological Society and lecturer in geography in the University of Cambridge. Visiting lecturers included Mr. F. E. Lumb, senior meteorological officer at the the Air Traffic Control Centre, Preston, who spoke on the organization of a meteorological station; Prof. R. F. Peel, of the Geography Department, University of Leeds, who gave a talk on the work of the Ruwenzori Expedition, Central Africa; Mr. N. Pye, lecturer in geography in the University of Manchester, who showed a film taken on a recent visit to the arid zone of Arizona; and Mr. R. G. Veryard, secretary of the Royal Meteorological Society and assistant director of the Meteorological Office at Harrow, who gave a lecture on certain aspects of climatology. Practical aspects of the course consisted of observation work; the Malham Tarn Field Centre is well equipped for this purpose, many of the necessary instruments having recently been provided, on permanent loan to the Centre, through the generosity of various instrument manufacturers. Various education authorities and the Education Department of the R.A.F. made it possible for some of the students to attend the course, which is approved for grants in suitable cases. A similar course will be held in late August 1954—a little earlier than this year so that more members of school teaching staffs and sixth-form students will be able to attend before the autumn term begins.

"Flying Saucers"

In an article in *Science* (118; 1953), C. C. Wylie, of the State University of Iowa, describes his investigations into the 'flying saucers' which have been much observed in the United States. Wylie concludes that these are simply reflected sunlight, having the following characteristics: (1) they are seen only when the sun is shining; (2) they are generally seen in the part of the sky opposite the sun; (3) there is only one sighting on each saucer, as the area for the critical angle is small.

Oil Pollution of the Sea

An international meeting of private citizens representing ten nations is to be held in London on October 27 next to press for action on the evil caused by oil pollution of the sea. The meeting will be held in the lecture hall of the Institution of Electrical Engineers, Savoy Place, London, W.C.2, from 11 a.m. to 4.30 p.m. The conference has been convened by the independent committee which has been working for the past two years to arouse public opinion on the need for action on the subject. The committee's task has been greatly assisted by the publication of an official report made to the Minister of Transport during the summer, which reached the conclusion that the only effective way of solving the problem was to prohibit ships from discharging waste oil into the sea. To achieve this, international agreement would be necessary. The purpose of the conference is to bring the findings of the report before public opinion in all countries. The chairman of the meeting will be Mr. James Callaghan, M.P., and the Minister of Transport will open the conference. Other speakers will include Mr. D. F. Anderson (chairman of the General Council of British Shipping), Lord Hurcomb, Sir Douglas Ritchie (chairman of the executive committee, Dock and Harbour Authorities' Association), Mr. Mogens Black (director of the Port of Copenhagen), M. Leon Lippens (mayor of Knokke, Belgium), Mr. Banks Belt (chairman of the Atlantic Waterfowl Council, New York) and Prof. J. Berlioz (Natural History Museum, Paris). A number of local authorities are sending representatives, and the Minister of Housing and Local Government has stated he will be prepared to sanction, on application, the expenses of one delegate to attend the conference from local authorities whose boundaries form part of the coastline. Admission will be by ticket only, which can be obtained by sending a stamped, addressed envelope to Miss P. Barclay-Smith, Secretary, Co-ordinating Advisory Committee on Oil Pollution of the Sea, I.C.B.P. (British Section), c/o British Museum (Natural History), Cromwell Road, London, S.W.7.

Modern Science and Christian Thought

A course of ten lecture-discussions designed to explore the contemporary form of the relation between science and religion is being held at St. Anne's House, Soho (57 Dean Street, London, W.1), on successive Thursdays until December 17 (October 22 excepted) at 6.30 p.m. The first lecture—on the history of the debate between science and religion—was given on October 8, and the future meetings will consider the following topics: creation and the expanding universe (Prof. C. A. Coulson); the scientific approach to historical study and Christian presuppositions about history (Miss C. V. Wedgwood); body, brain, mind and spirit—modern physiology in relation to the incarnational view of man; the scientific approach to psychology and Christian presuppositions about human nature—a dialogue between a psychologist and a Christian philosopher; the scientific approach to social science and Christian presuppositions about human relations—a dialogue between Prof. H. B. Acton and Prof. Michael Fogarty; man and evolution—modern biological science in

relation to Christian ideas of man's place in Nature (Dr. David Lack); scientific objectivity in relation to faith—a dialogue between Mr. H. J. Blackham and Mr. Michael Foster; space, time and matter—the world-view of modern physics (Dr. G. J. Whitrow); theology and the future of science—a general symposium. The method to be adopted at each meeting will be to survey the most modern findings and feelings of each of the relevant fields of science and see what relation they have to Christian presuppositions about the subject-matter of those sciences; the attempt will be made to discover where points of tension occur and whether this tension in different cases is due to the need for re-formulating certain Christian beliefs, revaluation of scientific theories or simply to an illegitimate claim on either side that its particular type of language is exclusively valid. The admission fee for each lecture is 1*s*. 6*d*. for members of St. Anne's House and 2*s*. for non-members.

X-Ray Analysis Group of the Institute of Physics: Autumnal Conference

The X-Ray Analysis Group of the Institute of Physics will be holding its annual autumn conference and exhibition during November 20–21 at the Institution of Electrical Engineers, Savoy Place, London, W.C.2. The conference will be divided into four sessions as follows: film methods and microdensitometry; counter spectrometry; the objects of the Equipment Sub-Committee; and identification by X-ray analysis. In addition, there will be an evening discourse on November 20 by Dr. R. W. G. Wyckoff, who will give a survey of X-ray diffraction in the United States. The exhibition will be on X-ray crystallographic equipment and will be divided into a commercial and a research section. The conference and exhibition are open to all, without charge, on completion of an application form, copies of which can be obtained from the Deputy Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1. The secretary of the conference is H. J. Goldschmidt, B.S.A. Group Research Centre, Greystones Hall, Greystones Hall Road, Sheffield 11.

Harwell Isotope School

Interest in the continually growing use of radioactive isotopes throughout the world and the demand from universities, hospitals and industrial organizations abroad are now at the rate of four thousand consignments for instruction, and this has compelled the Isotope School of the Atomic Energy Research Establishment, Harwell, to introduce an additional course for the second time this year. The School was started two years ago to teach the techniques of using and handling radioactive materials to scientists, doctors and industrial research workers. The series of courses planned for this year did not include one for July, but one had to be arranged and was filled. There is still such a heavy demand for places that another extra course will be held during November 16–December 11. Applications to be considered for this course should be sent to the Isotope School, Atomic Energy Research Establishment, Harwell, Berkshire. More than two hundred and fifty students have so far attended the school, from twenty different countries. Isotopes are now being sent out from Harwell at the rate of 11,000 a year, of which four thousand are exported. The fee is £40 for the course, and accommodation may be arranged for students at an additional charge of £7 7*s*. a week.

Chemistry and Physics of Synthetic Fibres

The Plastics and Polymer Group of the Society of Chemical Industry is arranging a symposium on "The Chemistry and Physics of Synthetic Fibres", to be held in the lecture theatre of the Institution of Electrical Engineers, Savoy Place, London, W.C.2, during March 24–26. Papers will be presented and discussed on the chemical and physical basis of fibre formation and the properties of fibres in relation to the molecular structure and conditions of formation, the phrase 'synthetic fibres' being interpreted in the broader sense, meaning material brought into a fibrous structure by a manufacturing process, irrespective of the source of the raw materials. In order to limit the scope of the symposium, the process of dyeing, the properties of textiles, the economics of the industry and historical surveys will not be included as major items, although reference may be made to such topics if they have an important bearing on the basic theme of the symposium. Papers will be presented in full, but will not usually take more than 30–40 minutes each. Preprints will be available, and authors should submit their manuscripts before November 1. Those with insufficient material for a full paper will be able to present their ideas in the discussions. All communications relating to the symposium should be addressed to Mr. A. R. Burgess, Plastics and Polymer Group, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

Announcements

Dr. A. A. Wells has been appointed chief research engineer and head of the Engineering Research Station, Abington (nr. Cambridge), of the British Welding Research Association; in addition, Mr. R. P. Newman has been appointed chief administrative officer of the Station.

The Institute of Metal Finishing has awarded its Westinghouse Brake and Signal Co., Ltd. Prize for 1952–53 to Dr. A. E. Davies, Mr. R. M. Angles and Dr. J. W. Cuthbertson, joint authors of a paper on the complex fluorides for the deposition of tin and tin alloys.

The annual conference of the British Institute of Management will be held at Harrogate during November 11–14. Further information can be obtained from the Director, British Institute of Management, Management House, 8 Hill Street, London, W.1.

The American Society for the Study of Sterility is offering a prize of a thousand dollars for an essay on the subject of infertility and sterility. Essays must be submitted not later than March 1, 1954. Further details concerning the competition can be obtained from the secretary of the Society, Dr. Herbert H. Thomas, 920 South 19th Street, Birmingham, Alabama.

The Royal Institute of Philosophy has recently announced its lecture programme for the session 1953–54. The session opens with a course of six lectures on "Fundamental Questions of Philosophy" by Dr. A. C. Ewing. All lectures are given on Fridays at 5.30 p.m. at University Hall, 14 Gordon Square, London, W.C.1, the first one being on October 16. The lectures are open to the public, and programmes for admission can be obtained free of charge upon enclosing a stamped addressed envelope to the director of studies, S. E. Hooper, at the above address.

SCIENTIFIC CIVIL SERVICE

PROMOTION OF INDIVIDUAL RESEARCH WORKERS

SPECIAL posts have again been created this year in the Scientific Civil Service under provisions included in the White Paper (Cmd. 6679; 1945) designed to provide for the promotion of individual research workers of exceptional merit. The promotions are effective from July 1.

Deputy Chief Scientific Officers

DR. S. G. BAUER has worked in the British Atomic Energy project since its earliest war-time days. He was a member of the British team in Canada, and returned to Great Britain when the Harwell establishment was opened. His work has been mainly devoted to the development of nuclear power reactors, and he has made great advances in the technology of the special materials and processes which such reactors require.

DR. S. J. FOLLEY, who since 1945 has been head of the Physiology Department of the National Institute for Research in Dairying, Reading, joined the staff of the Institute in 1932 and has since then been working on various physiological aspects of lactation and reproduction. Much of his research has been on the endocrinology of these related activities, on mammary growth and on the biosynthesis of milk fat, and he has made substantial contributions to knowledge in each of these three fields. He was a Rockefeller Foundation Fellow in 1938, studying at Yale University. He is at present chairman of the Society for Endocrinology. He was elected a Fellow of the Royal Society in 1951.

DR. P. FORTESCUE worked before and during the Second World War with the Bristol Aeroplane Co., Ltd., on gas turbine development, making notable advances in axial and centrifugal compressors and in automatic control systems. At the Atomic Energy Research Establishment, Harwell, he is in charge of the Engineering Laboratory, working primarily on heat-transfer problems connected with nuclear reactors, and on the development of special pumps and compressors.

DR. G. G. MACFARLANE joined the Telecommunications Research Establishment of the Ministry of Supply in 1939 after carrying out research on theoretical problems in electrical engineering at the Technische Hochschule, Dresden, as Matthew Gray Scholar of the University of Glasgow. He has done important fundamental work in quantum mechanics and electromagnetic theory. He has also been prominent in the investigation of theoretical problems arising in the development of radar equipment and has made valuable contributions in this field.

Senior Principal Scientific Officers

MR. G. E. BACON joined the Atomic Energy Research Establishment, Harwell, in 1946, after war-time service in the Telecommunications Research Establishment on the development of ground radar equipment, particularly aerial systems. At Harwell he has worked on the application of X-ray and neutron diffraction techniques to the study of the solid state. An important part of this work has been research on the structure of graphite and investigations of single-crystal methods of neutron diffraction analysis.

DR. E. H. BATEMAN'S varied experience included structural engineering, educational work in the R.A.F. and lecturing in civil engineering at the University of Birmingham before he joined the Ministry of Home Security in 1939 to work on camouflage. In 1944 he transferred to the Armament Design Establishment, Ministry of Supply, and in 1952 to the Royal Aircraft Establishment. While at the former Establishment he not only carried out much valuable design work but also made special investigations into the analysis of mechanisms. In addition, he produced his well-known second-order iterative solution for solving algebraic and transcendental equations and for the inverse interpolation of functions, together with his development of matrix solutions for vibration problems involving structural discontinuities and for statistical problems which are beyond the practicable range of existing methods. At the Royal Aircraft Establishment he has done valuable work on thermal stresses caused by kinetic heating of high-speed aircraft and guided weapons.

MR. J. B. BRATT joined the National Physical Laboratory, Teddington, in 1937, where he has carried out valuable work in the measurement of aerodynamic forces on oscillating aerofoils for both subsonic and supersonic flow. His applications of electrical methods to the technique of measurement are outstanding. They have been of very great value both in providing experimental checks on results given by theory, and in exploring difficult problems where theory is uncertain—for example, those concerned with nearly or completely stalled flow, effects of Reynolds number, influence of compressibility especially in the transonic region, and effects of aerofoil thickness. The information obtained from such work is vital for the prediction of the behaviour of modern high-speed aircraft.

MR. R. DONALDSON joined the National Physical Laboratory, Teddington, in 1928 after two years as demonstrator in the Physics Department of the University of Edinburgh. He has been primarily occupied with the theoretical development of the quantitative evaluation of light, covering the whole field of colorimetry, heterochromatic photometry and spectrophotometry, and has made notable contributions to all these branches of the subject by the design of instruments and the development of techniques to meet the ever-widening requirements of industry. His name first became prominent in this field with the development of his trichromatic colorimeter, which he described in 1935 and which is now the most widely used trichromatic colorimeter in the English-speaking countries. His most recent work is concerned with the re-determination of the constants of the C.I.E. system of colour measurement and with problems of fluorescence.

Dr. S. Neumark had considerable experience before the Second World War as a lecturer and research worker in aerodynamics and applied mathematics in Warsaw, at the Technical University, the Aerodynamic Institute, and the Institute of Aeronautical Research. During 1937–39 he was professor of mechanics in the Polish Air Force College, Warsaw, and while in the Polish Air Force he joined the Royal Aircraft Establishment, Ministry of Supply, remaining there on demobilization. He has done distinguished work in theoretical aerodynamics, especially investigations into problems of stability and control and in fluid motion, including theoretical flow over swept-back wings, and he is widely known for his researches in these fields.

Dr. W. G. S. Parker entered the Royal Aircraft Establishment, Ministry of Supply, in 1936. He worked initially on a wide variety of physico-chemical problems in the aircraft field and made many valuable contributions. Since 1946 he has been concerned with the difficult problems of the mechanism of burning and decomposition of oxidizing fuels and propellants, and his work in this sphere has earned him an international reputation. In particular his research on carbon formation and on the structure of diffusion flames has advanced considerably the understanding of combustion in air flames and has had important applications in the study of fire prevention.

Dr. S. M. Partridge, for two years prior to joining the D.S.I.R., held a Beit Memorial Fellowship for Medical Research, working at the Lister Institute for Preventive Medicine. He joined the D.S.I.R. in 1942 to assist a team at the Low Temperature Research Station, Cambridge, studying dehydrated meat, and was responsible for the development on the pilot-plant scale of a process for its manufacture. Since the Second World War, in the course of his investigations on connective tissues (cartilage, elastic tissues, etc.), he has made notable contributions to analytical methods in biochemistry. He was a pioneer in the application of partition chromatography on filter paper to the analysis of sugars and in the development of displacement chromatography of organic compounds using ion-exchange resins. His contributions to biochemistry are finding numerous applications, not only to foods but also to medical research and other fields of applied biochemistry.

Mr. E. O. Powell was with the Chemical Defence Experimental Establishment, Ministry of Supply, during 1941–46, and after a short period on industrial research re-joined the Ministry of Supply in the Microbiological Research Department in 1947. His versatility and insight have enabled him to make valuable contributions in such diverse fields as bacteriology, chemistry, mathematics and physics. He has done particularly important work in the development of micro-manipulative techniques for the study of individual bacterial cells, and also in bacterial genetics.

Mr. G. D. Robinson joined the Meteorological Office in 1936. He has made valuable detailed studies in atmospheric radiation and in the transfer of heat, momentum and water vapour between the ground and the air, and his published papers on this work are widely recognized as important contributions. These investigations of basic problems of energy exchange in the atmosphere are to be extended.

WORLD FEDERATION OF SCIENTIFIC WORKERS

ASSEMBLY AT BUDAPEST

THE World Federation of Scientific Workers held its third assembly during September 12–14 in Budapest, at the invitation of the Hungarian Association of Scientists and Engineers. Thirty-five representatives of organizations of scientists in Bulgaria, Canada, China, Czechoslovakia, Denmark, France, Great Britain, Hungary, India, Poland and the U.S.S.R. attended the sessions. The proceedings were opened by the president, Prof. Frederic Joliot-Curie. The president's speech emphasized the need for scientists to inform the public of the useful things which science can provide, and to try to promote international exchanges of scientific literature and of personal visits as a contribution to improving international relations. Apart from organizational matters, the Assembly discussed certain questions of general interest to scientists. Reports on the salaries and conditions of work of scientists in various countries represented at the Assembly were presented. Special attention was devoted to the difficulties which are at present being experienced in connexion with exchanges of scientific books and periodicals. It is greatly to be hoped that an improvement in these exchanges can be achieved by the concerted action of all scientists in all countries. It was also decided to extend the publications of the Federation with the view of giving a presentation of the positive and constructive way in which science could contribute to the welfare of all peoples if it were freed from many of its present restrictions.

The resolutions passed by the Assembly made the following points: (*a*) that scientific workers everywhere should strive to secure the peaceful solutions of all international differences, so that less attention will be given to military preparations and more to the peaceful uses of science; (*b*) that governments could and should, by international negotiations, reach agreement regarding the prohibition of weapons of mass destruction; and (*c*) that academic freedom should be preserved and that the restrictions to which scientists are subjected should be reduced.

Laboratories and museums of all kinds were visited by delegates to the Assembly, and Hungarian scientists showed great pleasure in discussing scientific matters with their guests. To judge from the laboratories which have been recently completed and from those which are now in the process of building, it may be said that scientific institutions are rapidly developing and that large funds are available for this purpose. Many university teachers and research workers are engaged in writing text-books in the Hungarian language. The number of students in universities and institutes of higher education has increased seventeen-fold since 1939. During the same period the number of technical universities has increased from one to five, and the number of scientific books published each year by a factor of ten. Parallel with this great internal growth in education and research, there has developed a need for better contact with foreign science.

A novel feature of this Assembly was the holding of lectures on scientific subjects, given to the various Hungarian scientific societies, and they evoked great interest and discussion. Among the lecturers were: Prof. E. Aubel (France), on the mechanism and role of the biological reduction of nitrates; Prof. J. D.

Bernal (Great Britain), on (1) X-ray analysis of materials, and (2) the structure of proteins; Prof. K. Bratanov (Bulgaria), on the application of vegetative and sexual hybridization in stock-breeding; Dr. M. Degerbøl (Denmark), on prehistory and zoology; Prof. E. Grillot (France), on luminescence of crystalline minerals; Acad. L. Infeld (Poland), on the influence of Copernicus on the development of physics; Prof. Y. Le Grand (France), on recent researches on optical physiology; Acad. V. P. Nikitin (U.S.S.R.), on electrical welding; Sir Robert Watson-Watt (Great Britain), on the education of scientific workers; Dr. W. A. Wooster (Great Britain), on diffuse X-ray reflexions and the physical properties of crystals.

Excursions were arranged for the delegates to various centres of interest, in particular to the new steel town of Stalinvaros, to the ancient royal seat of Vesperen, to the district surrounding Lake Balaton and to a collective farm. Receptions were given by the Hungarian Academy of Sciences and by various delegations. Visits to the opera and ballet were also arranged. Just before the last session of the Assembly, a concert was given by the following distinguished musicians: Annie Fischer, Alexander Svéd, Ede Zathureczky, Mihaly Szèkely and Maria Gyurkovits. The hospitality extended to the guests was truly magnificent and they will long remember their stay on the island Margitszigit in the Danube.

Prof. F. Joliot-Curie (France) was re-elected president. Other officers re-elected included Prof. J. D. Bernal, Prof. C. F. Powell (vice-presidents), Dr. W. A. Wooster (treasurer), and Dr. E. G. Edwards (honorary secretary). The total membership of the scientific and technical organizations affiliated to the Federation has risen from 44,000 in 1951 to 136,770 in 1953, and it is distributed over thirteen countries.

W. A. Wooster

SYMPOSIUM ON GEOCHEMISTRY AT ZURICH

A SYMPOSIUM on geochemistry was held in Zurich during August 11–13 under the auspices of the International Union of Chemistry. It was presided over by Dr. M. Fleischer and by the local chairman, Prof. C. Burri, with Prof. T. F. W. Barth acting as secretary. More than sixty members, representing eighteen countries, were present. This meeting was the first international gathering of geochemists.

The material read at the symposium was divided into two groups: (1) reports relating to the problem of organizing, completing and making available geochemical data; (2) papers on geochemistry and allied subjects. The first group of communications included the following reports: by M. Fleischer on the geochemical work of the Geochemistry and Petrology Branch of the U.S. Geological Survey and on the progress of the revision of Clarke's "Data of Geochemistry" (Bull. 770, U.S. Geol. Surv.); by Marjorie Hooker on the progress made in the revision of Washington's "Chemical Analyses of Igneous Rocks" (Prof. Pap. 99, U.S. Geol. Surv.); by W. Müller on the geochemical work of Gmelin Institute; by P. Rosbaud on the publication of geochemical papers in *Geochimica and Cosmochimica Acta* (Pergamon Press, London); by K. Rankama on the compilation, revision and organization of current geochemical work; and by T. F. W. Barth on current geochemical research throughout the world. The second group comprised some twenty-five papers dealing with a variety of subjects, such as the geochemistry of certain elements, the distribution and abundance of elements in ground water, sea water, sedimentary and igneous rocks, the association of uranium with mineral hydrocarbons, the uranium content of deep-sea sediments, the geochemistry of petroleum and allied substances, the minerals of pegmatites, the composition and origin of meteorites, petrochemistry and petrogenesis, and the use of the periodic system of geochemistry. A fuller report of this meeting will be published in *Geochimica and Cosmochimica Acta*.

The meeting took place in the Mineralogical and Petrographical Institute of the Federal Technical College in Zurich by invitation of Prof. C. Burri and with the assistance of the staff of the Institute. After the meeting, a group of members of the symposium took part in an excursion to the Eastern Gotthard Massif (August 14–15), led by Prof. C. Burri.

During the symposium six members of the Commission on Geochemical Localization of the Elements of the International Union of Chemistry, who were present, met and, among other business, elected Prof. H. C. Urey as a member of the Commission in succession to the late Prof. P. Niggli, and Prof. C. Burri as an observer attached to the Commission. The composition of the Commission (subject to confirmation by the Committee of the International Union of Chemistry) is as follows: M. Fleischer (Washington), president; T. F. W. Barth (Oslo), vice-president; K. Rankama (Helsinki), secretary; and members, H. S. Brown (Pasadena), C. W. Correns (Göttingen), D. Guimaraes (Belo Horizonte), A. Holmes (Edinburgh), E. Raguin (Paris), S. I. Tomkeieff (Newcastle upon Tyne) and H. C. Urey (Chicago).

EFFECTS OF ATMOSPHERIC POLLUTION ON VEGETATION

ON September 9, the last day of the Liverpool meeting, Sections K (Botany) and K* (Forestry) of the British Association jointly discussed the increasingly important topic of the deleterious effects of chemical substances in the atmosphere on plant growth. It is all too well known that soot and gaseous products of combustion, such as sulphur dioxide, when released into the air over and around large cities and industrial areas, not only cause damage to buildings but also impair the health of animals and human beings. The damage to vegetation due to the same causes is less widely known but is very familiar to those who have to cultivate plants in forest, field, garden or glasshouse where atmospheric pollution occurs. In Great Britain the damage to glasshouse plants was especially noticeable during the unusually severe fogs that occurred during the winter of 1952–53. That the problem is not confined to Great Britain is shown by catastrophes such as those which occurred in the Meuse valley in Belgium in 1930, at Donora in Pennsylvania in 1948 and at Poza Rica in Mexico in 1950, in all of which localities much human illness and numerous deaths were shown to be due directly to short periods during which the atmosphere was more highly polluted than usual. A large-scale investigation of the damage to vegetation caused by

atmospheric pollution in California was undertaken under the auspices of the Selby Smelter Commission, the conclusions of which were published in 1915. More recently, an international commission was appointed to investigate similar damage at Trail in British Columbia. The outcome of this research was made known in a book published in 1939 by the National Research Council of Canada.

Dr. C. R. Metcalfe (Royal Botanic Gardens, Kew), who opened the symposium by referring to the facts outlined in the paragraph above, then described how evergreens, and particularly conifers, in the Kew neighbourhood become stunted in growth owing to the deposition of soot on the leaves, and indicated that soot forms an adherent scum on the roofs of glasshouses, from which it can be removed only by vigorous washing soon after it has been deposited, or by chemical means if the deposit is one of long standing. Experimental work at Kew has shown, however, that the more acute symptoms of ill-health that so frequently appear in plants that have been subjected to a polluted fog are due not so much to reduction in availability of light as to the presence of toxic substances in the atmosphere. Examples of these acute symptoms are the shedding of flowers and leaves by begonias and many other plants that make a fine display during the winter months, the blackening and death of buds and flowers of certain orchids, notably *Calanthes*, the scorching of the foliage of cinerarias and primulas and the almost complete destruction of such plants as *Coleus blumei*, particularly the varieties 'Sunset' and 'Golden Ball'.

One of the most important of these toxic substances is sulphur dioxide. Treatment of susceptible plants with low concentrations of sulphur dioxide such as are known to occur in a London fog induces similar symptoms to those exhibited by the same species of plants during foggy weather, provided the atmosphere is sufficiently moist and the temperature sufficiently high. Other experiments have shown that the damage sustained is progressively more severe as the concentration of sulphur dioxide in the air goes up. Yet another series of experiments showed that sulphur dioxide can be removed from air by passing it through a column of sphagnum moss soaked in a solution of sodium carbonate, and that air purified in this way is no longer toxic to plants. Then again it was found that the damage done can be substantially reduced by protecting the plants with paper bags, which appear to have the power of adsorbing small quantities of sulphur dioxide. After pointing out that the experiments at Kew have led to conclusions concerning the toxicity of sulphur dioxide that agree except in a few minor particulars with the views expressed by investigators in Canada and the United States, Dr. Metcalfe ended his survey by referring briefly to practical remedies that can, or might be, used for alleviating the unhealthy symptoms exhibited by glasshouse plants in foggy weather. The amateur and small-scale cultivator should not despise the protection that can be afforded by a paper covering; cracks between panes of glass can be reduced to a minimum by stopping them up; chimneys from boilers should be so situated that they do not emit sulphur dioxide in the immediate vicinity of the glasshouses they are intended to heat. The temperature and humidity of the atmosphere should be reduced as much as the nature of the plants being cultivated will allow, and the value of this practice has repeatedly been demonstrated in greenhouses and by experimental methods in the laboratory. While chemical treatments in glasshouses to counteract the acids in the atmosphere have not shown much promise, it should not be impossible to construct special houses into which purified air can be introduced. Those concerned with town planning should choose sites for horticulture where atmospheric pollution is not likely to be severe. In this connexion the direction of the prevailing wind is most important. It is clear, however, that no single remedy can be found except by reducing and, if possible, eliminating the sources of pollution.

Mr. T. R. Peace (Forest Research Station, Farnham) raised the question of how near to urban areas can trees be planted with any prospect of securing an economic return on the outlay. It was pointed out that this important problem is still far from being solved. Mr. Peace also stressed the difficulty of distinguishing symptoms such as those of Dutch elm disease or die-back of foliage and shoots caused by damage to roots in a heavy clay soil on one hand, and similar symptoms induced by a polluted atmosphere on the other. He described in some detail an occasion in June 1953 when considerable damage was sustained by trees on the Duke of Bedford's estate at Woburn. This damage occurred suddenly, and is believed to have been caused by the emission of fluorine from a neighbouring brickworks during a period when there was a wet fog, the relative humidity rising to 99 per cent at a temperature of 57° F. at 3.0 a.m., followed by a gradual rise in temperature and fall in relative humidity to 53 per cent by 3.0 p.m. on the following day. Conifers were more severely damaged than hardwood species. European larch was severely affected, the young shoots being killed outright. The distal ends of the current season's needles of Scots pine turned brown, and there was slight damage to Norway spruce, but Corsican pine sustained no damage at all. Similar damage occurred in the forest nursery as well as to more mature trees. Among hardwood species, slight damage to *Corylopsis* and *Rhus* was noted in the nursery, and *Pterocarya* shed its leaves.

Dr. J. K. C. Bleasdale (Botany Department, University of Manchester) described experiments in which seeds of various species of plants were buried in boxes of soil and grown in localities where the concentrations of pollution were known to be different. No visible effect of the pollution was noted in the plants raised in this way during the summer months, when the concentrations of pollution at all of the centres were relatively low; but, after the plants had passed through the winter, marked differences, corresponding to the degree of pollution, appeared in the health and vigour of the plants during the following spring. When hill pastures on farms in East Lancashire were ploughed and planted with selected strains of clovers and grasses from Aberystwyth, the increased pasture yields that were expected to accrue were not, in fact, realized.

Dr. Bleasdale agreed with the general belief that sulphur dioxide is one of the most noxious ingredients of smoke, and concentrations of from 0·5 part per million upwards are known to cause lesions on various types of plants. At concentrations below 0·5 part per million, lesions do not usually occur, and some of the previous investigators have claimed that growth is not seriously impaired below this critical concentration. Experiments in two small air-conditioned glasshouses in the Fallowfield district of Manchester showed, however, that prolonged treatment of the Aberystwyth strain of rye grass known

as *S*23 with air containing concentrations of sulphur dioxide that ranged from 0·01–0·06 part per million gave a dry weight yield that was 45 per cent below that of plants grown in air that had been purified by passing it through a water scrubber. Some evidence was found, however, that the effect of polluted air may be masked if the rye grass is grown on soil of especially high fertility. The greenhouse experiments were supplemented by others in the field at nine different sites. These showed that plants such as rye grass, cabbages and wallflowers, in which active photosynthesis occurs during the winter months, are seriously stunted when grown in a polluted atmosphere, the reduced growth being most marked where the pollution is most concentrated. Dr. Bleasdale ended by referring to the competition for land between building and agricultural interests, and reminded his audience that the spread of suburbia combined with smoke pollution is reducing food production to an ever-increasing extent that might well become serious. Possible remedies would be to breed smoke-resistant varieties of food plants, and to apply chemicals to the plants to counteract the sulphur dioxide in the atmosphere.

These three contributions were followed by a lively general discussion in which reference was made to many aspects of the subject, including the action of a polluted atmosphere in inhibiting the development of lichens and mosses, the increasingly poor outlook for planting woodlands in the future, and the complex nature of the combined influence of soil conditions and air pollution on plant growth. Prof. H. G. Champion (University of Oxford), who has seen the damage to vegetation in the neighbourhood of the Trail smelting works in British Columbia, said that considerable improvement had been effected there by the introduction of remedial measures at the works. From the views that were expressed it is quite evident that, apart from the damage done by soot and other solid particles emitted into the atmosphere, there is general agreement that sulphur dioxide is one of the most important causes of damage to vegetation. It must not be overlooked, however, that certain American investigators have claimed that other chemical substances, such as oxidation products of olefines, are also responsible. The discussion undoubtedly served a useful purpose in focusing attention not only on the serious damage to plant life that sometimes occurs but also on the complex of physical and chemical factors that play a part in causing this destruction. A complete solution of the problem is not likely to be quickly achieved for economic reasons; but it is to be hoped that success will come gradually through the combined endeavours of engineers, meteorologists, chemists and botanists. C. R. METCALFE

COMPARATIVE PHILOLOGY AND POLYNESIAN STUDIES

By PROF. ALAN S. C. ROSS
University of Birmingham

PHILOLOGY (or linguistics) consists of two parts, usually called descriptive linguistics and comparative philology, respectively. The latter is technical and esoteric (therefore its nature is not easy to describe shortly), whereas the former is of a nature altogether more obvious.

The main task of descriptive linguistics is, in fact, the answering of the question: What is the best, or even, what is a good way to describe language; or, to describe a particular language? It is very clear that the 'normal' answer to this question—namely: Languages may best be described in the terms in which Latin is conventionally described—is valueless when applied to the majority of languages. That is to say, 'Latin' grammar, with its sharp distinction between, for example, verb and noun, and its system of declension and conjugation, cannot afford us a frame for describing a language such as Tahitian, which has no trace of declension or conjugation and, apparently, has one massive part of speech corresponding to the Latin verb, noun, adjective and adverb taken together.

Some philologists consider that no satisfactory answer to the question: How may a language be described? has yet been given. Others, however, think that they have given an answer and have established, in several schools already somewhat at war with each other, the subject known as structural linguistics. The main centres of this new subject are, first, many American universities, and then the Universities of London, Paris and Copenhagen.

The second branch of linguistics, comparative philology, makes statements of which the following are the three main types: (1) 'English and German are related languages'; (2) 'the English word *stone* is philologically identical with the German word *stein*'; (3) 'an Anglo-Saxon long *ā* becomes a Modern English long *ō* (as in AS. *stān* MnE. *stone*'). Statements of all these types are technical and entirely non-obvious; the learner of comparative philology must be prepared to expend a good deal of hard work before he can expect to understand them.

The 'axiom' underlying statements of the first kind is simple to state; it is merely that 'Two languages are defined as related if, and only if, they were once one language'. Thus French and Spanish are related because, and only because, they were both once Latin. Developing this axiom in an obvious manner, it is easy to establish the concept 'Family of Languages'; for example, English, German, Dutch, etc., form the Germanic family of languages.

Comparative philology, in its modern sense, came into being at the beginning of the nineteenth century. One of its main tasks has been the arranging of the languages of the world into families of related languages, and great progress has been made in this field. To-day, the thousands of languages in the world stand arranged into hundreds of different families (with no relationship proved to subsist between any pair of the families). The next—and incomparably the more laborious—task is the production of all possible statements of the second and third types for each family. Only when this has been done can the comparative philology of a family be said to exist.

Even in pre-1914 Germany (where the subject flourished most), the number of comparative philologists has always been small, in comparison with the number of, for example, natural scientists. It is therefore scarcely surprising that, in the century and a half which has elapsed, it has not been possible to bring into being (still less to complete) the comparative philology of more than seven families, namely: (1) Indo-european (to which, for example, English, Latin and Russian belong); (2) Uralian (for example, Finnish, Hungarian and Samoyede); (3) Semitic (for example, Hebrew and Arabic); (4)

Turkish–Mongol–Tungus (sufficiently described by its name); (5) Bantu (for example, Zulu); (6) Dravidian (for example, Tamil); (7) Indonesian (for example, Malay).

The establishment of the comparative philology of the remaining families of the world may well take many centuries of research work, and the prospect has recently been darkened by the almost complete gulf which now separates the new and fashionable structural linguistics from the old-established comparative philology—a gulf which, in extreme cases, may extend to an actual despising by the structuralist of the rigid disciplines of comparative philology.

Comparative philology is of immense value and importance to other subjects, for, it must be remembered, it is unsafe to make even the simplest statement involving the history of a word (such as, that it is a borrowing from another language, or, that earlier it had a different meaning) without reference to a specialist in the relevant comparative philology. Such statements are, alas, often made without such reference and they are, naturally, always without value. Although comparative philology is so esoteric, its *results* are often much appreciated by non-philologists; to take two examples, common enough in Britain, the classical scholar uses such results with profit for Homeric criticism, and the results of English place-name study are of great value to the historian —though both are usually entirely ignorant of even the nature of comparative philology.

As already stated, the outlook for the establishment of a comparative philology for families of languages still without it is rather poor. There is, however, one exception to this statement and the purpose of the present article is to direct attention to it. There is, in fact, one family the comparative philology of which, at the moment untouched, could be established by a very small group of scholars in half a life-time's work. This family is Polynesian.

The reason why it is precisely Polynesian that, of all the 'untouched' families of the world, is in so exceptionally favourable a position, is that Polynesian is closely related to Indonesian, a family the comparative philology of which is in an extremely advanced state, by reason of the labours of generations of Dutch scholars. Furthermore, the Polynesian languages are few in number (Maori, Tongan, Hawaiian, Samoan and Tahitian are the principal ones), the relationship between them is very close (Hawaiian and Tahitian are scarcely more 'distant' than are German and Dutch), and, finally, their relationship to the Indonesian languages is also fairly close, being of somewhat the same order as is the relationship between Lithuanian and Russian. The Balto-Slavonic family consists of two branches—Slavonic (with, for example, Russian, Czech and Bulgarian) and Baltic (comprising Lithuanian, Lettish and Old Prussian); if we were to imagine that the comparative philology of Slavonic had been thoroughly worked out but that that of Baltic was still untouched (which is, of course, not the actual case), then this hypothetical state of work to be done would give us a very fair picture of the actual state existing in regard to Indonesian (worked out) and Polynesian (untouched).

It seems, then, desirable that a comparative philology of Polynesian should be inaugurated forthwith. How may this task best be accomplished?

Polynesian falls naturally under the head of 'Pacific Languages'—which term I here use to comprise (1) the Polynesian family; (2) the Melanesian family; (3) the very many different families of New Guinea; (4) the many different families of Australia. To-day, the study of Pacific languages is everywhere linked with either anthropology or structural linguistics. Neither of these linkings is likely to be of much value to the proposed comparative philology of Polynesian. It would not be desirable to attempt to turn either an anthropologist or a structuralist into a comparative philologist; anthropologists rather naturally tend to regard linguistics as a subordinate subject and I have indicated the attitude of the structuralists above. Furthermore, neither an anthropologist nor a structuralist is likely to have received any grounding in the disciplines of comparative philology. It seems, then, that the proposed comparative philology of Polynesian had better be essentially independent of both the subjects mentioned (though it might well have liaison with and, later, offer help to both anthropologists and structuralists).

The proposed study must, of course, be centred in some university or institute and not more than six choices present themselves.

(1) In London the School of Oriental and African Studies, which has recently had so many new linguistic developments (for example, as concerns Africa and South-East Asia), has shown a slight interest in Pacific languages. But this interest has been purely descriptive, indeed structuralist. Comparative philologists may regret that the languages in the Pacific field selected for study by the School have been mostly Melanesian (for example, Gilbertese), a family which offers no hope of the establishment of a comparative philology for many lifetimes, instead of Polynesian, which offers a real and present hope of such establishment. But it may be that, from the point of view of the structuralist, the Melanesian languages are more interesting.

(2) After a terrible record of neglect, first of its own aboriginal languages, then, even less excusably, of New Guinea languages from the end of the penultimate war onwards, Australian university life has at last begun to take a modest interest in these languages. Rather naturally, the study seems to be at least slightly subordinate to anthropology; but this is not the main difficulty, which is simply the enormous number of different languages requiring study. Australian philologists will surely be occupied for many decades with the plain task of describing them.

(3) At Honolulu there is a long-established tradition of Polynesian studies at the Bernice P. Bishop Museum. However, this interest is, in the main, anthropological and, furthermore, the supreme dominance of structuralism in the United States would be likely to militate against the establishment of any new comparative philology.

(4) In Paris two Pacific languages are admittedly taught at the École des langues orientales vivantes; these are Wailu (the major language of New Caledonia, a Melanesian language) and Tahitian (a Polynesian language). The instruction and interest here are, however, confined to the imparting of a practical knowledge of these languages to French people going to these areas, and there is no sign of any interest in comparative Polynesian philology, or even in any other Polynesian language.

None of the first four choices, neither London, Honolulu, Paris nor an Australian university, thus seems in any way especially suitable as a venue for

the proposed study of comparative Polynesian philology. The remaining two choices deserve, however, much more serious consideration.

(5) In Holland the comparative philology of Indonesian has a long and dignified tradition (the literature is, naturally, almost entirely in Dutch) and it is on Indonesian that the proposed comparative philology of Polynesian is, of course, to be based. At first sight, then, some Dutch university would seem particularly suitable for the establishment of such a study. But two points could be urged against this choice. First, Governments are not usually prepared to devote money to the languages of areas in which they have no territorial interest, and Holland has none in Polynesia. Second, who can forecast what deleterious effect the present rift between Indonesia and Holland may not have upon these studies hitherto flourishing in Holland?

(6) There remains only New Zealand. Here there has for long been an interest in Maori studies. At the moment this interest is oriented entirely in the direction of either anthropology or (by reason of American interest) of structural linguistics. But there seems no reason why an equal, or surpassing, interest in comparative Polynesian philology could not be built up. New Zealand has always been eminent in what is essentially a branch of comparative philology, in that, for its size, it has produced a quite undue proportion of scholars distinguished in Anglo-Saxon and Middle English (though it has, admittedly, exported most of them to Britain). New Zealand has another advantage: only here, in the whole of Polynesia, is there, at the moment, any likelihood of there existing a native speaker of a Polynesian language (namely, Maori) with sufficient preliminary education for it to be possible to turn him into a comparative Polynesian philologist.

It seems, indeed, that one of the New Zealand universities would be the ideal venue for the setting-up of the unit, which, it is proposed, will establish the comparative philology of Polynesian. The practical details of such a setting-up remain for consideration.

In the first place, it may be pointed out that the unit could well be a small one. A professor, two lecturers and a secretary could probably accomplish the whole task in a decade. By modern university financial standards, the expenditure for such a unit would not be all too great. But funds for three ancillary purposes would have to be provided.

(1) *Library*. Philology, much more than medicine and natural science, requires old books as well as new; nowadays, it is not possible to obtain the out-of-print books of any philology by second-hand purchase and, in the main, copies must be obtained by photographic aids (photostats, 'Copycats', microfilms, etc.). But, from the financial point of view, Polynesian is, in this respect, very fortunately placed, for its literature is, comparatively, very scanty. An initial expenditure of £1,000, plus an annual grant of £100, would probably be sufficient for the acquiring of a substantial Polynesian collection (the comparable figures for a Balto-Slavonic collection might well be £15,000 and £500).

(2) *Travelling*. The smallness of the library expenditure would, however, be more than offset by the high travelling expenses. Since Polynesian languages can only be learnt by speaking, it would clearly be desirable for members of the proposed unit to spend much time travelling in the Pacific. Furthermore, they would have to visit the Indonesianists in Holland from time to time (and on these European visits they would, of course, also have to keep in touch with other philologists in Europe).

(3) *Publication*. Naturally, the results of the establishment of the comparative philology of Polynesian would, in due course, have to be published. Probably a series of monographs, in conjunction with a periodical, would best meet the case here. Here perhaps it would be desirable to envisage the nature of the publications required. An adequate descriptive and comparative apparatus for an Indo-european language (and we must accept the same standard for Polynesian also) might consist of: (*a*) descriptive 'grammar' (declension, conjugation—in application to different parts of speech) and 'syntax' (uses of the same, word-order, etc.); (*b*) the complete catalogue of all things such as (for Modern English) 'Anglo-Saxon *ā* becomes Modern English *ō* (AS. *stān* MnE. *stone*)', mentioned above, and the historical *raison d'être* of all that is set out under (*a*) above; (*c*) a dictionary into the same, or some other language (in the latter case, with inverse dictionary also); (*d*) an etymological dictionary (that is, for English, the setting-out of all possible equations of Type English *stone* = German *stein*, mentioned above).

Thus, A. Heusler, "Altisländisches Elementarbuch" might serve as a (small-scale) model for (*a*) and (*b*) combined (in respect of Old Icelandic), the "New (or Oxford) English Dictionary" as a model for (*c*) and (*d*) combined (in respect of English).

In addition to the 'advanced' apparatus (*a*), (*b*), (*c*) and (*d*), there should be an 'elementary' apparatus also—something to help the beginner on his way to more serious methods of study (such as speaking); the standard Gaspey–Otto–Sauer grammars might serve as examples of this.

Owing to the nature of Polynesian languages (no declension or conjugation, virtually no parts of speech), there would be great difficulty in writing descriptive grammars of Type *a* (above). As already mentioned, it is not practicable for them to be written on the 'Latin' method—as can readily be observed from those already written. It may be doubted, too, whether the structuralists are in fact going to give practical help here. There seem to be only two possible solutions to the difficulty. First, to model the grammar on that of ancient Indonesian, by now well elaborated by the Dutch philologists, that is, to regard the phenomena of, for example, Tahitian as decay-products of those of Old Javanese; second, to write no grammars at all, but to relegate all that would be in them to the dictionaries. A study of the world's great dictionaries—for example, "New English Dictionary" (note, for example, the head-words *So* adv. and *Set* vb.), H. G. Liddell and R. Scott, "Greek–English Lexicon", J. and W. Grimm, "Deutsches Wörterbuch", "Groote woordenboek der nederlandsche taal", and "Svenska Akademiens ordbok"—will undoubtedly convince the reader that this method is practicable. The proposed 'Primers' would, on this second method, merely consist of text, literal translation and glossary modelled on the dictionary.

If this second method were adopted (and it is, I feel, the better one) the problem of publication becomes greatly simplified and is reduced to the following scheme.

(1) For each Polynesian language separately: (1) a dictionary, into English, modelled on the "New English Dictionary" and with inverse index; (2) a primer.

(II) For the aggregate of Polynesian languages, taken together: (1) a comparative phonology, that is, something setting out all results of the Type AS. *stān*: MnE. *stone* (mentioned above); W. Streitberg, "Urgermanische Grammatik", might serve as a model; (2) an etymological dictionary; A. Walde and J. Pokorny, "Vergleichendes Wörterbuch der Indogermanischen Sprachen", might serve as a model.

There is, finally, the question of selecting and training the proposed unit for the establishment of the comparative philology of Polynesian. All its members must, of course, be thoroughly conversant with comparative philology, and this end is probably best attained by their having passed through some quite conventional school of philology (such as 'English Language', 'French Language' or Sanskrit, as taught in Great Britain). Next they must have an adequate training in Indonesian, and this can only be gained by at least three years residence in Holland (and, possibly, some time in Indonesia). It is much to be hoped that at least one member of the unit will be a native speaker of Maori (one who had gone through an 'English Language' training in a New Zealand university would be ideal); it might well be desirable to invite a distinguished Dutch Indonesianist to spend at least some time as another member.

CHEMICAL RESEARCH LABORATORY, TEDDINGTON

REPORT FOR 1952

THE report of the Chemistry Research Board, signed by the chairman, Prof. E. L. Hirst, and the report of the director of the Chemical Research Laboratory, Teddington, Dr. D. D. Pratt, make up the contents of "Chemistry Research 1952", which has recently been published*. To these reports are appended a list of more than fifty papers submitted for publication during the year, and lists of the staff of the Laboratory, of metals held by the Pure Metals Committee, of standard substances available and of species in the National Collection of Industrial Bacteria. Both reports refer to the improvement in working conditions through the occupation of the new Radiochemical Building in May and of the Microbiological Buildings in November, thus easing the overcrowded conditions in the main building and enabling the construction of a mass spectrometer and research on high-temperature corrosion of metals by hot flue gases and by boiler-water to be commenced. Nevertheless, the Board records the opinion that the scientific staff is still too small in relation to the programme, though it merely expresses the hope that additional staff will be provided "when circumstances permit".

The Board's report again stresses the value of the work of the Corrosion of Metals Group. The value of the electrical capacitance method of measuring the rate of water uptake of a paint film on immersed metal has been further investigated with anti-corrosive paints and an anti-fouling paint, and an apparatus has been constructed in which specimens can be subjected to controlled amounts of spray solutions, infra-red and ultra-violet radiations. Studies of the mechanism of corrosion inhibition by potassium chromate and sodium benzoate using radioactive tracer techniques indicate that the former is more firmly held by the metallic surface. Bacteriological examination of a clay soil in which the expected attack on buried pipes had not occurred revealed the presence of a species of *Actinomyces* toxic to sulphate-reducing bacteria. Examination of a water-logged clay soil from a site at Hungate, York, in which ancient buried iron particles were excellently preserved in spite of the presence of sulphate-reducing bacteria, anaerobic conditions and the appropriate *p*H range for bacterial activity, showed that the activity of the bacteria was suppressed by concentrations of tannin of 0·01 per cent and upwards. In conjunction with the British Iron and Steel Research Association, an inquiry has been initiated into the incidence of buried water-pipe failure in Britain and the efficacy of cathodic protection. Other investigations have included a study of the effect of pressure on the rate of oxidation of copper at 100–250° C. and the use of film-stripping and microchemical techniques in a study of the influence of surface condition on the low-temperature oxidation of mild steel, while an investigation of the effect of small amounts of salts and particles left on metal surfaces subject to different treatments in metal-finishing processes has shown that blistering of paint on sheet-steel articles may be caused by salt contamination of metal surfaces arising in treatments prior to painting. The importance of humidity in the corrosion of steel has been confirmed in tests carried out in collaboration with the Institute of Petroleum Protective Panel, and good protective value has been obtained by temporary protective coatings in which corrosion inhibitors are incorporated in thixotropic suspensions of inorganic earths: although soft and easily removed when no longer required, these coatings do not flow from the protected surfaces on storage.

The Inorganic Group has completed its work on the elimination of arsenical impurities from germanium; further work has been carried out on the production of dicalcium phosphate from phosphate rock by the action of nitric acid followed by ammoniation, and studies of the action of sulphuric acid on an apatite from Uganda indicate that the apatite can be fairly readily converted to phosphoric acid provided the concentration of the sulphuric acid is carefully controlled. The study of the reaction between ferric oxide and ammonium sulphate has been continued; a search was commenced for possible sources of selenium from waste materials, and spectrochemical methods for detecting and estimating this element were being sought, as well as methods for determining phosphorus in organic compounds which can be applied to the determination of this element in ion-exchange resins. In collaboration with the Radiochemical Group, the carrier technique, used for the micro-estimation of thorium, has been adapted to the direct determination of tantalum and niobium separately in ores. The chromatographic process for the separation of these metals that has been worked out by the Radiochemical Group has proved simple and accurate for a wide variety of products, while the quantitative separation of palladium, platinum, rhodium and iridium by a chromatographic process has been practically completed, and preliminary experiments have shown that bismuth can be separated chromatographically from a solution containing nitric acid. Extension of the work on the adsorption and elution of complex cyanides of gold, copper and iron with 'Amberlite

* Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with the Report of the Director of the Chemical Research Laboratory for the Year 1952. Pp. iv+120+4 plates. (London: H.M.S.O., 1953.) 4*s.* 6*d.* net.

IRA 400' resin to the complex cyanides of nickel, cobalt, zinc and silver has led to the development of a method for the separation and recovery of these metals from solutions derived from the cyanidation of auriferous ores. New equipment constructed during the year includes apparatus for determining automatically the life of ion-exchange resins on continuous re-cycling with different solutions, and an automatic scanning device for filter-paper strips on which the separation of metallic salts containing radioactive tracers has been effected. The device provides a permanent quantitative record of the activity distribution. A scintillation counter has also been devised consisting essentially of a lead and brass housing for a photomultiplier with a heavy brass slide arranged so that a small silica cell can be brought easily and accurately in front of the photomultiplier cathode.

Some changes were made in the organization of the Organic Group during the year: the two Organic Intermediates Sections were amalgamated, and a new Standard Samples Section split off from the Purification and Measurements Section. Work on the introduction of functional groups into polystyrene resins through the chloromethylation reaction will in future be continued in the High Polymers Group, but the Organic Intermediates Section will continue to prepare substances that by polymerization or condensation will furnish new resins containing functional groups. An initial study of stearic acid containing palmitic acid by the differential vapour-pressure method, using an apparatus with mercury as the manometric liquid and a tap-less device for pressure equalization, showed that as little as 0·1 per cent of palmitic acid could be estimated. Measurements of the vapour pressures of pyridine bases continued, and the purification of *iso*-octane, methyl*cyclo*pentane, methyl*cyclo*hexane, ethylbenzene and *o* cresol has been followed spectroscopically. A method of estimating *iso*nicotinic acid in the presence of nicotinic, picolinic and dipicolinic acids has been developed in which a Spekker absorptiometer is used with an Ilford filter 604. Quantitative analyses have been made by infra-red absorption spectroscopy of mixtures of picolines, 2 : 6-butidines and 2-ethylpyridine. In collaboration with the National Physical Laboratory, the Organic Group has made progress in a programme for determining the heats of combustion of organic compounds by improvements in chemical technique and in the calorimeter, and the heats of combustion of four pyridine bases have been measured at 25° C. under standard conditions. The isotope dilution method has been applied to the determination of naphthalene in a high-temperature coal tar and in the evaluation of the efficiency of naphthalene-recovery plant. A study of the mechanism of the Kolbe–Schmitt reaction has been commenced, and the benzoin reaction with terephthaldehyde has been reinvestigated. Attempts have been made to prepare selective ion-exchange resins of well-defined constitution by introducing suitable functional groups into polymers. The addition of carbon monoxide, acetylene and α-picoline has brought the list of standard substances available for distribution as reference specimens to thirty-six items, and the temperature and pressure of acetylene at its triple point have been determined.

In view of the outstanding performance of polyvinyl alcohol films as semi-permeable membranes in non-aqueous systems and the specific recommendations of the High Polymers Committee that studies on the fundamental factors controlling the semi-permeability of polymer films should be initiated and that membranes suitable for use in aqueous systems should be investigated, the effort of the High Polymers Group devoted to work on membranes has been increased. In the absence of additional staff, it has been necessary to stop work on covalent reactions of functional groups in polymers and to reduce that on ion exchange. The major items in the research programme of the Group are new studies on the ion-exchange and allied properties of polymers and studies on the semi-permeability of polymer films: with both topics much attention is being given to possible industrial applications of new materials or processes developed during the work. The programme of research on the use of surface-sulphonated polystyrene in ion-exchange chromatography has been completed, and work was commenced on the preparation of insoluble resins containing functional groups capable of reactions other than ion exchange. Investigation of the applications of polyvinyl alcohol membranes has shown that these membranes considerably extend the scope and accuracy of somatic pressure measurements on polymer solutions, and their impermeability to solute and ready transfer of solvent permit the use of simple unsymmetrical osmometers.

The Microbiology Group has intensified its fundamental investigations on sulphate-reducing bacteria. These have included studies of the hydrogenase activity of *Desulphovibrio desulphuricans*, of its carbon metabolism, including the pyruvate metabolism by which certain strains can grow without sulphate, its variability and its viability. Investigations of the formation of sulphide in the water bottoms of petrol-storage tanks led to the recommendation that the water should be changed frequently and sodium chlorate added where necessary, as this inhibits both sulphate reducers and the corrosion of steel. A continuous method for the cultivation of sulphate-reducing bacteria is being employed by a team from the Chemical Research Laboratory at the Microbiological Research Department, Porton, of the Ministry of Supply, and a marked increase in the rate of sulphate-reduction has been achieved by the use of a suitable nutrient medium. Further development of the microbiological production of sulphur depends largely upon the availability of adequate supplies of suitable fermentable wastes as sources of carbon. The National Collection of Industrial Bacteria now maintains 620 strains, of which 52 were added during the year.

On the advice of the Pure Metals Committee, nickel, rhenium, thallium and titanium have been added to the stock of high-purity metals. Investigations on the oxidation of steel at moderately high temperatures have been commenced with special reference to the possible improved resistance of steels for boiler superheater tubes, and advice on the control of corrosion in heat-exchange systems resulted in successful treatment of a system at the Atomic Energy Research Establishment, Harwell, and of cooling coils in fermenter vessels used in the manufacture of penicillin and streptomycin. Advice has also been given on the choice of materials for the construction of a water-filtration plant in Australia, for heating coils in oil tankers and for a new sewerage scheme in Lancaster, and on the protection of wharf steelwork at Kuwait in the Persian Gulf and the prevention of corrosion in lining pipes in artesian wells in Madras.

HYDRATION STRUCTURE OF DEOXYRIBONUCLEIC ACID AND ITS PHYSICO-CHEMICAL PROPERTIES

By Dr. BERTIL JACOBSON*

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RECENTLY, various helical structures have been proposed for deoxyribonucleic acid[1-3]. That suggested by Watson and Crick[3] is of special interest, since it is shown here to have a remarkable similarity with the structure of the tetrahedral water lattice. This similarity makes it possible to explain the great tendency of deoxyribonucleic acid to interact with water, and also to interpret several strange properties of its solutions. Hammarsten[4], thirty years ago, suggested in a general manner that these properties were due to the state of hydration of the deoxyribonucleic acid molecules; the details of his explanation can now be formulated more exactly.

It has been postulated that water has a regular quasi-crystalline structure only slightly different from that of ice[5]. In studying the details of the ideal water lattice, it has been found here that the interstitial volume has a spatial arrangement like that of helices parallel to the *a*-axes, as illustrated in Fig. 1. Helices of certain different dimensions exist, and their pitch is a multiple (n) of the water lattice units in the *a*-axis direction and thus amounts to $4{\cdot}514 \times n$ A. at 0° C. and approximately $4{\cdot}74 \times n$ A. at 25° C. (calculated using as thermal coefficient of linear expansion the value 2×10^{-3} deg.$^{-1}$). Pitches with certain multiples of those given are also possible. The integer n also denotes the number of coaxial helices of the same pitch and the same diameter that can be coiled around the same *a*-axis. The diameter of the interstitial helices is fixed for each value of n. If a cylindrical or helical section of water is removed from the ideal water lattice parallel to any of its three *a*-axes, a cavity is formed, the surface of which has oxygen atoms arranged in a helical manner similar to that of the interstitial helical space. The oxygens are free to form hydrogen bonds with a macromolecule placed in the cavity.

The Watson and Crick structure for deoxyribonucleic acid contains two helical polynucleotide chains coiled around the same axis with the phosphates on the outside and the basic groups from the two chains joined together on the inside of the helix. There are ten residues per turn and the pitch is 34 A. The outer diameter is about 20 A. and the inner diameter[6] about 12 A.

As is seen in Fig. 2, the Watson and Crick structure fits well into the water lattice. The outer helical envelopes of the polynucleotide chains through their phosphoric groups are the same as the $n = 7$ helix in the water lattice. The diameter in the water lattice is 21·8 A. and the pitch is 33·2 A. The inner helical envelope does not correspond to a simple water lattice helix but to one with $n = 3{\cdot}5$ with a double pitch. In the plane perpendicular to the *a*-axis, the fitting is excellent, as is seen in the upper part of Fig. 2. The ten nucleotide residues per turn along the outer helical envelope might be able to form hydrogen bonds (if the fitting in the *a*-axis direction allows it) with every other of the twenty (18–22 depending upon how the helix is placed) hydrogen-bonding positions in the water lattice. Corresponding to the ten basic groups along the inner helical envelope there are ten (or twelve) hydrogen-bonding positions in the water lattice. In the plane perpendicular to the *c*-axis and in the direction of the *a*-axis (lower part of Fig. 2), there are seven water lattice units per ten residues in the polynucleotide helix. This poorer fitting in this direction is to be expected, since the length of the deoxyribonucleic acid molecule varies with the ionic strength of the solvent[7]. From studies of the equatorial X-ray reflexions of the deoxyribonucleic acid molecule, it has been assumed that the two helices should be displaced from each other by about three-eighths of the fibre-axis period[6]. From considerations of fitting with the water structure, the displacement could be any fraction of seven, and three-sevenths or two-sevenths might also agree with X-ray data.

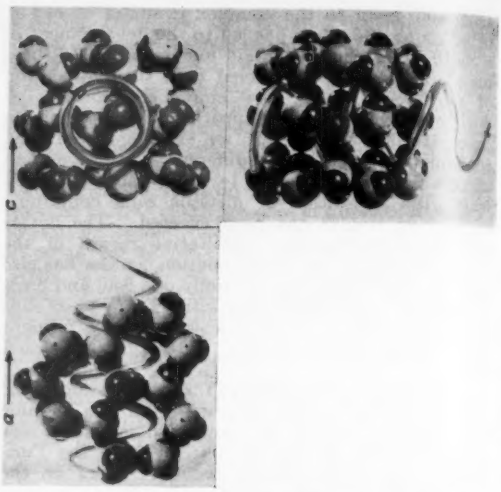

Fig. 1. Ideal water lattice viewed from three mutually perpendicular positions. The interstitial space has a helical shape as indicated by the rubber spiral

Light-scattering and streaming birefringence measurements have both shown that the deoxyribonucleic acid molecules contract on addition of small amounts of electrolytes[7]. The maximum reduction in length was 30–40 per cent, occurring when the ionic strength was increased from 0 to 2×10^{-2} *N*. It is highly probable that the Watson and Crick model is the structure of the contracted molecule. If the contracted form is now assumed to be exactly 30 per cent shorter than the extended form, the latter would have a distance between the residues along the helical axis equal to the dimension of the unit cell in the water lattice, $a = 4{\cdot}74$ A. The extended form would then fit very well into the water lattice. Most of the physical properties indicate this is actually the case, as will now be discussed.

Previously, and independently of these findings, it was concluded from streaming dielectric investigations[8] on electrolyte-free solutions that the surface of the deoxyribonucleic acid molecule had the property of being able to order the water molecules to form a more regular ice-like structure. The mechanism can be explained on the following basis. Due to structural similarities and also to hydrogen-

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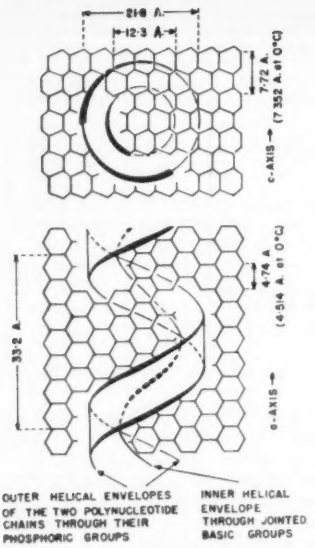
21·8 A.
12·3 A.
7·72 A.
c-AXIS → (7·352 A. at 0°C)
33·2 A.
4·74 A.
(4·5/4 A. at 0°C)
a-AXIS →
OUTER HELICAL ENVELOPES OF THE TWO POLYNUCLEOTIDE CHAINS THROUGH THEIR PHOSPHORIC GROUPS
INNER HELICAL ENVELOPE THROUGH JOINTED BASIC GROUPS

Fig. 2. Network is the water lattice where straight lines represent hydrogen bonds between oxygen atoms represented by intersections. The helical structure is the deoxyribonucleic acid model proposed by Watson and Crick. Dimensions given are for the water lattice at 20° C. if not otherwise stated

bonding between the deoxyribonucleic acid macromolecules and the water lattice, the thermal vibrations of the lattice are reduced. This leads to a more regular structure and therefore to an increase in hydrogen hybridization, resulting in an increased dipole moment of the water molecules[5]. Since this might be a possible explanation of the fact that ice has a higher dielectric constant than water (at low frequencies), it also explains the very high dielectric constant observed in electrolyte-free solutions of deoxyribonucleic acid[9,10]; the magnitude of this constant can scarcely be accounted for in any known way other than a structural change of the water of hydration of the macromolecules. This ordering effect of the water lattice must be effective over distances many times the diameter of the deoxyribonucleic acid molecules.

The contraction of the deoxyribonucleic acid molecules upon addition of small amounts of electrolytes explains why the osmotic pressure[4], the viscosity[4] and the dielectric constant[10] all decrease rapidly when the ionic strength is increased from 0 to 10^{-3} N. The extended form of the deoxyribonucleic acid molecule (as occurs in salt-free solutions) has, as proposed above, a structure on the surface that fits excellently into the water lattice and therefore orders a large volume of the surrounding water to a more regular ice-like structure. When the molecules contract on the addition of very little salt, the fitting over large distances along the surface of the macromolecule is impaired, and from the ice-like hydration shells water which was previously bound is made free, a process that apparently reduces the concentration of the hydrated macromolecular aggregates. This results in a reduced osmotic pressure. Also, since the regularity of the water lattice is decreased its rigidity is diminished[11], causing a decrease in viscosity. Furthermore, the reduced lattice order results in a smaller dielectric constant.

Time effects of the properties of deoxyribonucleic acid solutions can be explained as arising from a mutual slow adaption of macromolecular and water lattice structures leading to a slow building up or breaking down of the 'crystallized' ice-like hydration shells. The decrease in viscosity and in dielectric constant[9] on streaming is probably the result of such a breakdown due to the applied velocity gradient.

In certain electron micrographs of dried solutions the molecules are arranged in an irregular hexagonal manner[12,13]. This can be explained as a long-range ordering effect by the water lattice. Since the deoxyribonucleic acid molecules tend to become parallel with any of the three a-axes in the water lattice, a triangular, rhomboidal or hexagonal arrangement is probable.

Watson and Crick claim that their model suggests a copying mechanism for the genetic material. If their proposed mechanism is correct, the water structure must be of ultimate importance for the separation process of the two polynucleotide chains. The ten hydrogen-bonding positions in the water lattice can easily take over the hydrogen bonds between the basic groups in the helical chains and thus enable a separation with small amounts of energy. Further, the excellent fitting with the water structure in the extended form, which possibly might be a straight-chain molecule, also makes a separation of the two chains possible with low energies.

[July 22.

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ACCELERATION OF FLOWERING IN PARTIALLY VERNALIZED GRAIN OF PETKUS WINTER RYE BY SUBSEQUENT TREATMENT AT HIGH TEMPERATURE

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IT is now well known that the acceleration of flowering brought about in winter rye by exposure during germination to periods of low temperature can be in part annulled by exposure to temperatures above 15° C. given immediately after vernalization. The degree of reversal of vernalization achieved depends (1) on the duration of the low-temperature treatment, (2) the temperature-level and duration of the subsequent heat treatment. The vernalized condition becomes progressively stabilized and irreversible as the duration of low temperature is prolonged, and after twelve weeks of vernalization subsequent heat treatment has no effect on flowering[1].

In the course of further work in 1952 on the relationship between the degree of devernalization achieved by varying durations of high temperature following immediately after different periods of vernalization, a new effect of temperature was discovered. In these experiments longer periods of heat treatment than hitherto were employed—up to six weeks at 20° C. and 25° C., respectively—and it appeared that such prolonged heating of partially vernalized grain led to an intensification of vernalization.

As the growth of the grain was restricted by limiting the water content during treatment to 50 per cent of the oven-dry weight, it is clear that these effects are independent of growth during germination of the partially vernalized grain. Further, it has been shown (unpublished data) that neither Petkus spring rye nor unvernalized or fully vernalized winter rye are affected in their flowering behaviour by similar heat treatments. The effect is thus confined to partially vernalized grain under conditions where free growth is constrained by water shortage.

Tables 1 and 2 present experimental data carried out with plants grown in sand culture under conditions of constant seventeen-hour day-length. The effect on flowering is shown both by final leaf number and the days to anthesis counted from planting out at the end of the temperature treatment.

The data in Table 1 show that treatment at 20° C. for periods of 3–6 weeks has led to no devernalization, but on the contrary a marked acceleration of flowering has resulted, as may be seen by comparison with the values for the control set. The effect is evident both in leaf number and time to anthesis. The longer the exposure to 20° C. the greater the acceleration of flowering. The final leaf number of the set given 20° C. for six weeks does not differ significantly from that of grain vernalized for nine weeks and unheated ($10{\cdot}2 \pm 0{\cdot}3$). Short periods of heat treatment at 20° C. following upon six weeks of vernalization are known to have a devernalizing effect[1]; but with the shortest duration in this experiment (three weeks) no devernalization occurred.

The series treated at 25° C. show marked devernalization after exposure for six and twelve days; but with three and six weeks treatment the devernalization effect has disappeared, and these sets do not differ in flowering behaviour from the unheated controls.

In Table 2 a similar set of data are presented for plants grown from grain vernalized for four weeks before being given heat treatment.

Table 1. Effect on Flowering of Petkus Winter Rye Vernalized for Six Weeks and then Immediately Exposed to Temperatures of 20° C. and 25° C. for Varying Durations

Temperature of heat period	Duration of heat treatment in days	Mean final leaf number	Mean days to anthesis
20° C.	42	$10{\cdot}9 \pm 0{\cdot}3$	63·3
,,	35	$10{\cdot}3 \pm 0{\cdot}2$	63·1
,,	28	$12{\cdot}6 \pm 0{\cdot}6$	73·4
,,	21	$11{\cdot}9 \pm 0{\cdot}3$	71·6
25° C.	42	$15{\cdot}9 \pm 0{\cdot}7$	103·8
,,	21	$15{\cdot}5 \pm 0{\cdot}6$	104·0
,,	12	$18{\cdot}9 \pm 0{\cdot}5$	145·6
,,	6	$17{\cdot}1 \pm 0{\cdot}4$	121·3
Unheated control vernalized six weeks	0	$15{\cdot}4 \pm 0{\cdot}5$	105·6
Unheated control vernalized nine weeks	0	$10{\cdot}2 \pm 0{\cdot}3$	

Note. The number of replicates varies from 40 to 48

Table 2. Effect on Flowering of Petkus Winter Rye Vernalized for Four Weeks and then Immediately Exposed to Temperatures of 20° C. and 25° C. for Varying Durations

Temperature of heat period	Duration of heat treatment in days	Mean final leaf number	Mean days to anthesis
20° C.	42	$18{\cdot}2 \pm 0{\cdot}7$	134·4
,,	35	$15{\cdot}7 \pm 0{\cdot}7$	110·3
,,	28	$17{\cdot}9 \pm 0{\cdot}6$	139·7
,,	21	$18{\cdot}1 \pm 0{\cdot}6$	148·7
,,	12	$20{\cdot}6 \pm 0{\cdot}4$	179·5
25° C.	42	$20{\cdot}7 \pm 0{\cdot}5$	172·9
,,	21	$21{\cdot}1 \pm 0{\cdot}3$	183·7
,,	12	$21{\cdot}3 \pm 0{\cdot}3$	192·6
,,	3	$21{\cdot}4 \pm 0{\cdot}4$	188·5
Unheated controls vernalized four weeks	0	$19{\cdot}6 \pm 0{\cdot}4$	162·6
Unheated controls vernalized six weeks	0	$15{\cdot}4 \pm 0{\cdot}5$	

Note. The number of replicates varies from 38 to 46

The set given 20° C. shows a marked devernalization when heated for twelve days; but continued heating removes the effect and an acceleration of flowering is obtained after three weeks, and this becomes more marked as the heat treatment is prolonged, as comparison with the unheated controls shows. The behaviour of the set heated for five weeks is similar to that of unheated grain vernalized for six weeks, and thus the effect of heat is equivalent to that of an extra two weeks at low temperature.

At 25° C. short periods of heat treatment have resulted in devernalization greater than that following 20° C., but with prolongation of heating devernalization is absent, and both final leaf number and days to anthesis approach the value for the unheated controls.

The effect of a prolonged period at high temperature in accelerating flowering of partially vernalized grain is in agreement with deductions from the schema suggested by Purvis and Gregory[2]. It is necessary to assume that the postulated thermostable end-product of the vernalization reaction (substance *B* in the schema) increases autocatalytically and that the rate of this reaction increases with temperature. Evidence that the end-product of vernalization increases in the plant has already been put forward[3] and is deduced from the fact that removal of the apex of the main shoot and of several successive generations of branches fails to destroy the vernalized condition of the plant, which flowers normally.

The effects of high temperature following a restricted period of vernalization are thus twofold: (1) a devernalization due to removal of a labile intermediate (the reaction *A*, *A′* in the schema); (2) the self-perpetuation of the stable end-product (*B* in the schema). The total effect of a heat treatment after partial vernalization will thus depend upon the relative rates of these two processes.

A further experiment has shown that there is no effect of high temperature on the flowering of spring or fully vernalized winter rye, from which it would appear that in these cases flowering is not determined by the concentration of substance *B* but must be controlled by subsequent photoperiodic reactions.

Further work to elucidate these effects is in progress, and a full account will be published in due course. [Aug. 25.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

A Host-Protein Component of Influenza Viruses

EXPERIMENTS designed to unmask deeper antigenic components of influenza viruses by heat degradation of their type-specific surface antigens yielded evidence of relationship between virus types *A* and *B* based upon their possession of a common antigen. The antigen concerned was found to be almost indistinguishable from a component of the host tissues (chick embryo) in which the viruses were propagated, which at once aroused suspicion that it might be merely contaminant material adsorbed on the virus. The presence of an antigenic component in purified virus preparations of types *A* and *B*, which was also demonstrable in normal allantoic fluids, was first reported by Knight[1], who used a precipitation test with hyper-immune rabbit sera and viruses purified by differential centrifugation. It has been pointed out that reliance upon centrifugation for virus purification is open to the objection that centrifugation merely selects particle size and density, and it has been shown by Knight[2] himself that the normal allantoic fluid antigen is of similar size to the influenza viruses.

Attempts have been made in this laboratory to obtain irrefutable evidence that the host component is not an adsorbed contaminant but an integral part of the virus structure.

*PR*8 virus from infected allantoic fluids has been purified by four successive cycles of adsorption and elution using human red cells. This process is regarded as being essentially enzymic and therefore highly specific. The eluates, both untreated and heat-treated sufficiently to ensure destruction of the specific surface antigens, have been used as the antigens in cross-serological tests by means of a micro complement-fixation test[3]. Antisera against untreated virus were prepared by immunizing rabbits with infected allantoic fluids; but for the production of antisera against heat-treated virus, fourth-cycle eluates were used in order to ensure complete absence of antibodies against contaminant material. The rabbits were given two spaced injections and bled at the height of the secondary response, a technique which avoids the cross-reactions concomitant with hyper-immunization.

The results of four representative experiments from a very large number giving consistent results are shown in Table 1. They reveal the existence of a relatively thermostable antigen, distinct from the labile specific antigen, in this type *A* strain of virus. The thermostable component is demonstrably present in either untreated or heat-treated virus.

It has not been possible until very recently to prepare fourth-cycle eluates of type *B* virus (*Lee* strain) of adequate potency; consequently satisfactory heated-*Lee* antisera have not been available. Preliminary experiments, however, with first- or second-cycle reagents leave no doubt that a similar relatively thermostable antigen is present in the type *B* virus. Although full reciprocal cross-tests have not yet been done for the reason stated, the recently produced fourth-cycle *Lee* eluates have been tested against the *PR*8 antisera. The results included in Table 2 indicate the identity, or extremely close similarity, of the thermostable antigens of the two virus types *A* and *B*. Table 2 also includes the results of tests which show that the heated *PR*8 antisera will fix complement with aqueous extracts of normal chorioallantoic membranes. Antisera from rabbits immunized with such heated extracts, however, although potent against the homologous antigen, give at best only slight fixation with the heated virus antigens. This indicates a slight but significant immunological difference between the membrane and viral antigens, and is cogent evidence against the criticism that the latter represent merely adsorbed contaminant material.

Table 1. CROSS COMPLEMENT-FIXATION REACTIONS BETWEEN HEATED AND UNHEATED 4TH-CYCLE ELUATES OF *PR*8 VIRUS AND CORRESPONDING RABBIT ANTISERA.
Figures indicate complement-fixation potencies measured in arbitrary logarithmic units. 0 = no fixation.

Exp.	Test antigens	Complement fixation potency of sera prepared against: unheated *PR*8	heated *PR*8
1	*PR*8 unheated	>28	15
	*PR*8 heated 60° C./40 min.	0	11
2	*PR*8 unheated	15	17
	*PR*8 heated 60° C./40 min.	8	18
3	*PR*8 unheated	15	21
	*PR*8 heated 60° C./40 min.	8	>13
4	*PR*8 unheated	15	16
	*PR*8 heated 60° C./45 min.	1	7

The normal chorioallantoic membrane antigen would appear to be of the Forsmann type. It is extractable with 96 per cent alcohol and will withstand boiling; also the antibodies of the homologous antiserum can be readily absorbed out with sheep red cells. Attempts to extract the viral antigen in a similar manner are beset by the difficulty of preparing sufficient bulk of highly purified virus; but work to this end is now under way.

Another approach to the problem has been the disintegration of purified *PR*8 virus by multiple cycles of freezing and thawing with the object of releasing additional demonstrable thermostable antigen[4]. Serial samples removed during the course of such treatment show progressively less antigen for a number of cycles; but in some experiments a subsequent sudden and sharp rise has occurred. We interpret this phenomenon as the expression of the shifting balance between degradation of antigen and its release by disruption of the virus particle.

The results so far obtained do not indicate conclusively whether the thermostable antigen represents

Table 2. CROSS COMPLEMENT-FIXATION REACTIONS BETWEEN VIRAL AND HOST-TISSUE ANTIGENS

Test antigens		Complement-fixation potency of sera prepared against: heated normal chorioallantoic membrane	heated *PR*8
*PR*8 4th-cycle eluates	1: heated 60° C./40 min.	3	16
	2: heated 60° C./40 min.	0	16
	3: unheated		14
	4: heated 60° C./45 min.		4
Lee 4th-cycle eluates	1: heated 60° C./40 min.	0	14
	2: heated 60° C./1 hr.		6
Normal chorioallantoic membrane extracts	1:	16	12
	2:		12
	3:		7
	4:		16

host material incorporated as an intrinsic part of the virus particle, or merely adsorbed so firmly on the particle that it is able to pass through four adsorption–elution cycles. The slight immunological difference between the chorioallantoic membrane extract and viral antigens, the fact that the former antigen is considerably more thermostable than the latter antigen and the phenomenon of antigen fluctuation during the process of virus disintegration, lend support to the former alternative.

This work was supported by a grant from the Medical Research Council.

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Development of Virus in the Cell Nucleus

The nuclear polyhedral viruses of insects offer a unique opportunity for the study of virus behaviour in the cell. By knowing that the dominant focus of virus activity is in the cell nucleus, there is the advantage of being able to concentrate attention on a small and very definite site. The characteristic rod-like shape of the virus particles is an additional advantage in facilitating their recognition.

We have examined under the electron microscope a long series of very thin sections of nuclei of the silkworm (*Bombyx mori*) at various stages of infection, and by this means have built up a fairly convincing picture of the way the virus seems to arise in this restricted area. This study arose out of the discovery, in formalin-fixed diseased nuclei, of a peculiar structure which we have called the 'nuclear net'[1], and the sequence of events seems to be briefly as follows. At first, prior to the formation of the nuclear net, the nucleus becomes greatly enlarged. Next, the chromatin bodies begin to clump together to form the nuclear net; at this stage no virus bodies are visible. A little later, the rods begin to form and can be seen protruding from the central chromatic net and from the peripheral chromatin. The apparent metamorphosis of material of the chromatic net to virus rods is extremely interesting. At very high powers the net can be seen to consist of a fibrillar structure, and these fibrils seem to thicken to the normal diameter of the virus. The virus rods are then apparently pushed out into the nuclear ring zone (Figs. 1 and 2).

Following this, many free virus rods accumulate in the nuclear ring, but there are no membranes around the rods such as occur inside the polyhedral crystals (Fig. 2). In the next stage the polyhedral protein begins to accumulate in the ring zone and to aggregate around the virus rods. In some of our micrographs it is possible to see the rods actually being embedded in the polyhedral protein, giving a sculptured effect.

In the final stage, the polyhedra form and almost fill the nucleus. At this stage there are no free virus rods or loose polyhedral protein left in the nuclear sap. From our examination of a large number of sections and from the manner in which the virus rods appear to form in the chromatic masses, we are drawn to the tentative conclusion that this virus

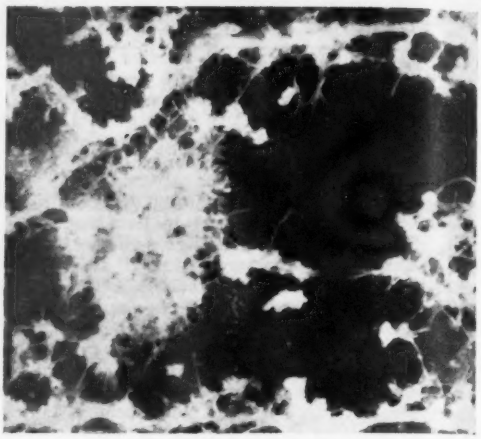

Fig. 1. Very thin section of a diseased nucleus of *B. mori*; the chromatic mass is to the left centre of the nuclear ring zone. Note the virus rods protruding from the central mass and the peripheral chromatin. (× *c.* 16,000.) *Photo: S. Vernon Smith*

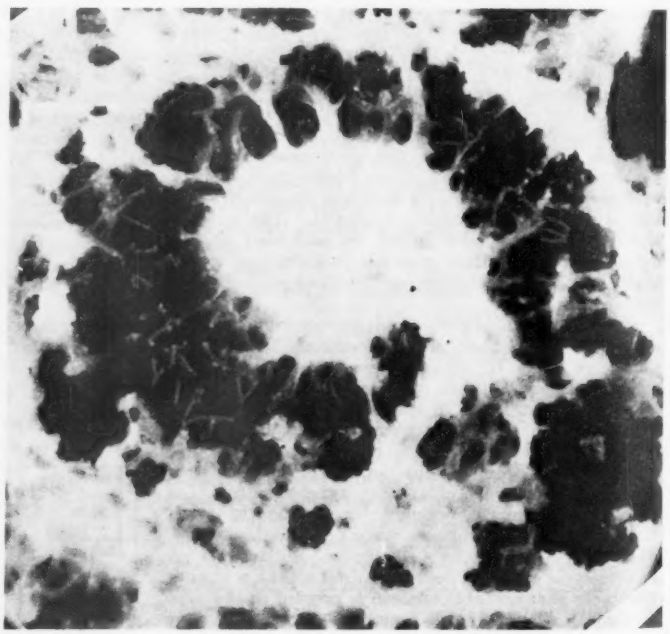

Fig. 2. Similar to Fig. 1. The ring zone contains many free virus rods without surrounding membranes; note the bunches of rods protruding from the chromatin. (× *c.* 16,000.) *Photo: S. Vernon Smith*

behaves much less like an organism than a differentiated product of altered cell metabolism.

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Growth Cycle of Ectromelia Virus in Mouse Liver

MANY workers have found that the multiplication of viruses occurs in definite cycles, each involving several stages, namely, adsorption and entry to host cell, a loss of part or all of the infectivity, a 'lag' phase during which no new infective virus can be demonstrated, a period of intracellular rise in infectivity, and finally release of this virus followed by invasion of a fresh population of susceptible cells. We have studied the intracellular multiplication of ectromelia virus in mouse liver, using intravenous inoculation and assaying the infective titre of the liver at intervals. We have found that over a range of inocula from 10^8 to 10^{10} *LD*50 about 30 per cent of the inoculum is adsorbed to the liver in five minutes. Inocula of 10^9 *LD*50 infect practically all the liver cells within five minutes, as measured by a histological method[1].

We have found that the multiplication of ectromelia virus also occurs in definite stages. After adsorption there is a rapid fall in infectivity to less than 1 per cent of the initial (five-minute) titre, then a lag period, followed by a rise back to the five-minute titre. Next there is a period of little multiplication followed by a rise in titre, then this last cycle is repeated. This is illustrated in Fig. 1, in which each point represents a pool of two or three mice. When two or more points on a growth curve are obtained from a single mouse the same stepwise rise in titre is found. Such growth curves are obtained with an average dose of one or more *LD*50 per liver cell, so infection of previously uninfected cells would be quite insufficient to account for the final rise in titre. It appears that multiplication takes place at some intracellular site and the infectious units so produced initiate multiplication on further intracellular sites in the same cell, resulting in the final increase in titre.

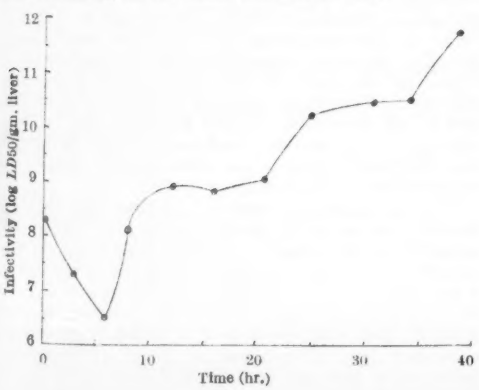

Fig. 1

Furthermore, we have been able to infect liver cells with as many as 20 *LD*50 per cell, assuming 10^8 liver cells per gram of liver. Even with this multiplicity of infection there is no auto-interference, that is, all twenty particles multiply independently of each other, and reach as high a titre as do lower initial doses.

These two findings would suggest that the fundamental virus-synthesizing centres must be sought at a sub-cellular level.

This work will be reported more fully in a subsequent paper.

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Contribution of Side-Chains to the Infra-Red Spectra of Proteins: the 6·5-μ Band

THE strong bands at 3 μ, 6 μ and 6·5 μ which dominate the absorption spectra of proteins in the fundamental region, and which have been observed as well in N-monosubstituted amides and in synthetic polypeptides, have been attributed to vibrations of the peptide links between the amino-acid residues forming the structural backbone of the protein molecule[1]. It has been established, however, that, in most proteins, side-chains carrying ionizable groups are joined to the polypeptide backbone, and that at the isoionic point the protein exists in the form of dipolar ions. Of the ionizable groups which have been identified, carboxyls occur in the greatest number and may be expected to contribute significantly to the absorption processes in the spectral region of interest.

We have studied the absorption of the carboxyl groups of synthetic polymeric acids and ampholytes in solutions of heavy water (which permit examination of the spectral region 5–8 μ [2]) and have found that the band at 5·87 μ (1,703 cm.$^{-1}$), characteristic of the un-ionized group, disappears upon addition of base, and is replaced by a very intense band at 6·40 μ–6·45 μ (1,560–1,550 cm.$^{-1}$), and by another, less prominent one at 7·10 μ (1,410 cm.$^{-1}$). These changes in the absorption spectrum, which for polymethacrylic acid are shown in Figs. 1*A* and 1*B*, are in agreement with observations on simple fatty and amino-acids, in which the 6·4-μ and 7·1-μ bands have been attributed to the unsymmetrical and symmetrical valence vibrations of COO^- respectively[3]. Although in proteins the 6·4-μ band coincides with the strong peptide absorption at 6·5 μ, it has been possible to establish the contribution of carboxylate groups by working in heavy-water solution, in which the hydrogens in the peptide linkages are completely exchanged for deuterium and the band characteristic of the peptide vibration is shifted to longer wavelengths, probably 6·95 μ (1,440 cm.$^{-1}$). As is evident from Fig. 1*C*, deuteration of isoionic bovine plasma albumin does not eliminate the absorption in the 6·5-μ region—a band remains, centred at 6·4 μ; upon addition of deuterium chloride to the solution, however, this band disappears and is replaced by a shoulder on the low wave-length side of the 6·08-μ band, as shown in Fig. 1*D*. Simultaneously, the

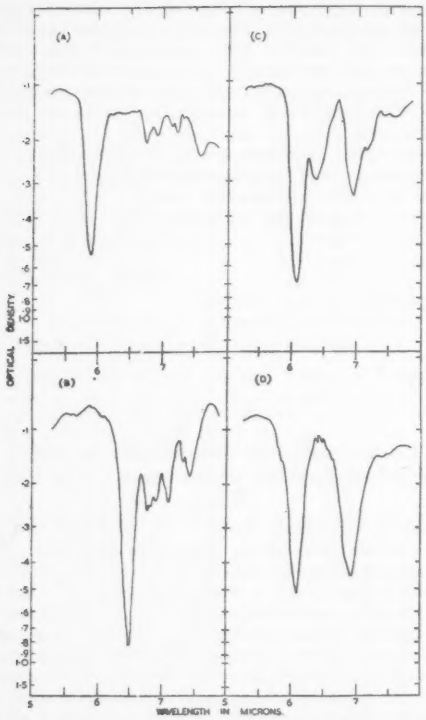

Fig. 1. Infra-red absorption of (*A*) polymethacrylic acid in heavy water solution (6·4 per cent); (*B*) polymethacrylic acid in 0·4 *N* sodium deuteroxide; (*C*) isoionic bovine plasma albumin in heavy water solution (7·5 per cent); (*D*) isoionic bovine plasma albumin in 0·3 *N* deuterium chloride

shoulder at 7·13 μ, observable in isoionic solutions, also disappears. Addition of an equivalent amount of sodium deuteroxide again restores the bands at 6·4 μ and 7·1 μ. These shifts must be attributed to the changes in the ionization of the carboxyl groups concomitant with *p*D changes in the protein solution.

It is apparent that the envelope of the 6·5-μ band of undeuterated proteins will, on the low wavelength side, depend upon the state of ionization of the protein molecule. Conclusions concerning changes in the arrangement of polypeptide chains, based upon the frequency criteria of Ambrose and Elliott[4] as applied to this region, must therefore be treated with reserve unless it can be demonstrated that the contribution of carboxyl groups has not been significantly altered.

This investigation, a fuller account of which will be presented in a subsequent communication, was supported by Contract *N*6 *onr*-23224 with the Office of Naval Research and Contract *DA*-44-109-*QM*-1037 with the Quartermaster Corps.

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Aspartate–Glutamate Transaminase in a Red Halophilic Bacterium

Little information is available on the metabolism of the red halophilic bacteria, although they represent a most interesting ecological group of organisms and are of some importance in the packing, pickling and curing industries. In a survey of their respiratory activity it was observed that resting cells did not oxidize readily the common carbon compounds usually employed, but actively oxidized glutamic, aspartic and other amino-acids. This observation prompted further study, in the course of which it was discovered that these bacteria possessed an active aspartate–glutamate transaminase system. The results of this work with *Pseudomonas salinaria*[1] are presented in this preliminary report.

Cells of *P. salinaria* were harvested from a three-day culture grown on the medium devised by Katznelson and Lochhead[2] but modified to contain glycerol as the carbohydrate addition. Cells were washed once with 0·025 *M* phosphate buffer, *p*H 8·0, containing 15 per cent sodium chloride. Since intact cells of this organism readily oxidized glutamate and aspartate, transamination was conducted in nitrogen. Cell-free preparations, on the contrary, did not oxidize these two acids and transamination could be accomplished equally well in air or nitrogen. All such tests were conducted with conventional Warburg respirometers at 37° C.

The aspartate–glutamate transaminase was indicated qualitatively by demonstrating the production of glutamate in a reaction mixture containing a source of enzyme and the sodium salts of α-ketoglutaric and aspartic acids as substrates. Glutamate was identified chromatographically with 75 per cent ethyl alcohol as the solvent. Enzyme activity was evaluated quantitatively by determining formation of oxaloacetic acid by the aniline-citrate procedure[3].

The aspartate–glutamate transaminase in *P. salinaria* proceeded optimally at *p*H 8·0, yielding a distinct glutamic acid spot on paper and, after a suitable incubation period, the expected amount of a β-keto-acid, presumably oxaloacetic acid, as indicated by the amount of carbon dioxide produced on tipping aniline-citrate into the main compartment of the reaction vessel.

The effect of sodium chloride on the transaminase activity was determined by centrifuging equal quantities of a cell suspension (of standardized turbidity) and resuspending in 0·025 *M* phosphate buffer (*p*H 8·0) containing the required concentration of sodium chloride. When suspended in salt-free buffer or one containing 1, 2 or 4 per cent sodium chloride the cells plasmoptysized completely in a matter of seconds. In the presence of 8 per cent sodium chloride there was also noticeable deterioration in cell structure, but not at 16 per cent sodium chloride. The results presented in Fig. 1 suggest that between 4 and 8 per cent sodium chloride is required for optimal enzyme activity.

This transaminase system was partially resolved into a coenzyme and protein moiety by ammonium sulphate fractionation[4]. Cell-free preparations were obtained by plasmoptysizing cells in buffer containing 4 per cent sodium chloride. The transaminase was removed from solution by saturation with ammonium sulphate and was redissolved in 4 per cent sodium chloride buffer. Data presented in the accompanying table show that at least partial resolution of the enzyme was effected by dialysis of the redissolved

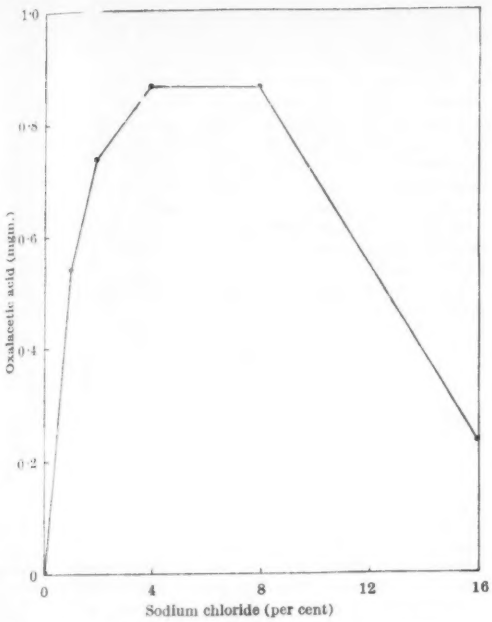

Fig. 1. Effect of sodium chloride on aspartate–glutamate transaminase

precipitate against 16 per cent sodium chloride buffer. The activity of this preparation was doubled by the addition of the ammonium salt of pyridoxal phosphate. Activity of the preparation dialysed against salt-free buffer could not be restored by additions of pyridoxal phosphate and 4 per cent sodium chloride. It would appear, therefore, that this enzyme system possesses a minimal requirement for sodium chloride below which there is an irreversible loss of activity.

RESOLUTION OF A TRANSAMINASE IN *P. salinaria*

Cell-free preparation dialysed against 0·025 *M* PO_4 buffer *p*H 8·0 (per cent NaCl in buffer)	Additions		Transaminase activity (mgm. oxaloacetic acid)
	Pyridoxal-PO_4 (μgm./vessel)	NaCl (per cent)	
0	0	0	0
	27	0	0
	27	4	0
16	0	0	0·488
	27	0	0·989

A detailed account of these experiments will be published elsewhere.

We wish to thank Miss M. I. Chisholm for technical assistance.

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Structure of Wool

In earlier investigations of the structure of wool[1], two fractions were obtained by peracetic acid–ammonia treatment of the keratin. One fraction was found to be soluble in weak ammonia, leaving behind an insoluble residue of 5–10 per cent in non-medullated specimens. The following is a report of an investigation by X-ray and infra-red methods of such specimens obtained under controlled conditions of extraction. Slurries of the insoluble residue were dried down to form films so that, wherever possible, X-ray and infra-red studies could be made on the same samples. Films of the soluble wool keratin were also made which were capable of investigation by the two methods.

The validity of the original investigations has been questioned by Woods *et al.*[2], who concluded from a repeat of the experimental work that the insoluble fraction was not in the β-form but rather that this modification was caused by an α → β transformation of the original insoluble material when the extraction temperature was raised from 20° C. (approximately) to 40° C. It was therefore suggested by these workers that the differences noted by one of us (F. H.[3]) in the original experiments were due to an artefact.

In earlier infra-red work on proteins by Elliott[4] it has been shown that the wool fibre in its normal state contains a certain proportion of β-protein, although it is well known that the structure of wool has in the past been identified by X-ray methods solely with the α-protein structure. On the other hand, in the case of feather keratin[5], which gives a β X-ray diagram, there is clear evidence from its infra-red spectrum of the presence of an α-component in the structure. Thus the infra-red method gives an overall picture of the polymer structure, whereas the X-ray method confines itself essentially to the crystalline components of the system.

In the present work the infra-red observations were made in the region of the strong carbonyl stretching frequency at 1,600–1,700 cm.$^{-1}$. Ambrose and Elliott[6] have shown that a slight shift in this frequency takes place in going from an α- (1,656 cm.$^{-1}$) to a β- (1,630 cm.$^{-1}$) protein configuration. Thus, using these frequencies as the basis of identification of the α- and β-components of the specimens, it has been shown that: (*a*) In the film made from the soluble keratin there is only evidence of an α C=O stretching frequency (1,656 cm.$^{-1}$). This is shown on curve I of Fig. 1. (*b*) The X-ray diagram of this film gave an α-keratin configuration, and when filaments were made by extrusion of this material an orientated α-diagram comparable with that from natural wool was obtained (see Fig. 2).

In the case of the insoluble fraction, several additional observations of interest were noted. (*a*) For films of the insoluble residue made at 20° C. the infra-red spectrum showed a peak at 1,656 cm.$^{-1}$ characteristic of the α-form with a definite shoulder at 1,630 cm.$^{-1}$ characteristic of the β-form (see Curve II, Fig. 1). (*b*) When the film was heated to 30° C. in water, after drying there was no change in the relative intensity of the β-shoulder of the curve.

The X-ray diagrams of these specimens, however, showed wide differences in the crystalline components of the films. (*a*) At 20° C. the characteristic α X-ray diagram was not present, but the 4·65-A. β-protein reflexion was diffuse. With increase of temperature of extraction up to 30° C., however, the

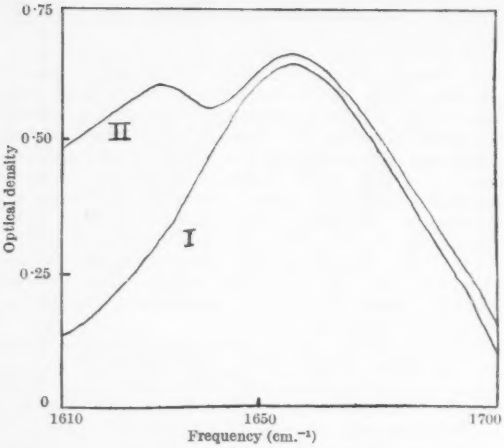

Fig. 1

β-line became more defined. In the case of a film heated in water for ten minutes at 30° C. and afterwards dried the diffraction diagram gave a strong ring at 4·65 A. (*b*) Further, it has been shown (private information, P. Alexander) that the photograph of orientated fragments of the insoluble phase of wool gave a resolution of the 4·65-A. diffuse arc around the equator of the X-ray diagram. (*c*) In an experiment in which the slurry was extruded through a fine jet to form a pseudo-filament the filaments examined were found to have little or no orientation, but there was a transformation of the diffuse ring into a sharp and strong reflexion at 4·65 A. This would suggest that stressing the insoluble particles may lead to a crystallization of the β-phase. Further, in some of the original work carried out by one of us the separation of the slurry was achieved by centrifuging, and it is possible that this method of extraction of the slurry at 20° C. may well transform the β-phase into a crystalline component, as did apparently the extrusion process in the experiment described above.

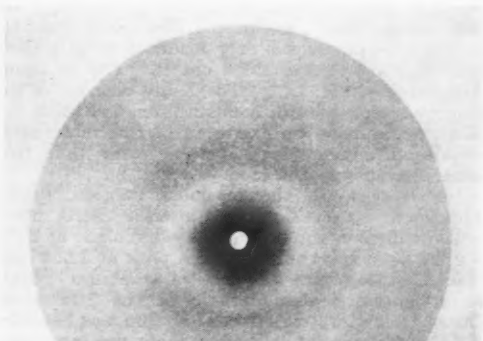
Fig. 2. X-ray diagram of regenerated keratin from wool showing oriented α-structure

From these experiments, therefore, it would appear that the presence of the β-phase in the insoluble fraction of wool is a true phenomenon as measured by the infra-red method. Further, its relative proportions under the conditions cited are constant in any one sample; but its unambiguous identification from an X-ray diagram may depend upon (1) its degree of crystallization which can be modified by its manipulation, or (2) the orientation of particles of the insoluble material in certain cases.

Further work is at present in progress, and a more detailed presentation of the results will be given in another place.

This work was financed by the Wool Textile Research Council, to which two of us (T. P. M. and G. J. W.) are indebted for fellowships.

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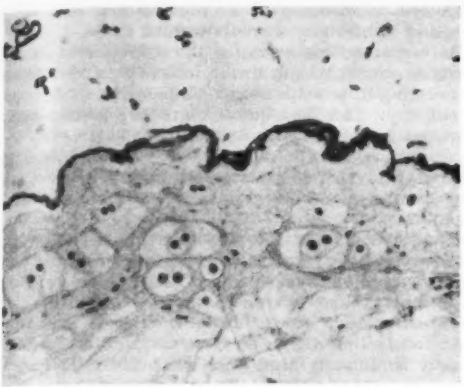
Demonstration of Keratin with Aldehyde-Fuchsin

Pearse[1] reported that keratin is demonstrated by the Schiff reagent after oxidation with performic acid. He suggested that the technique would be improved if a chromogenic agent were found which reacted readily with sulphonic and sulphinic acids but not with other basophilic groups such as carboxyl groups.

Studies[2,3] in our laboratory on the staining reactions of Gomori's aldehyde-fuchsin[4] with various mouse tissues have shown that this stain has a strong affinity for tissue elements with a relatively high sulphur content. Mast cell granules and cartilage matrix, tissue elements containing highly sulphated mucopolysaccharides, stain intensely with aldehyde-fuchsin without previous oxidation. Cystine-containing elements, keratin and beta-cell granules of the islets of Langerhans, react strongly with the stain after oxidation with periodic acid or acidified permanganate. Since it is known that sulphonic groups may be produced by the oxidation of cystine[5], it appears that aldehyde-fuchsin has an affinity for acid sulphur groups such as the sulphuric groups of sulphated mucopolysaccharides and the related sulphonic groups produced by the oxidation of cystine.

In the work described above, the tissues were oxidized for five minutes with periodic acid solution *B*[6] or for two minutes with a mixture of equal parts of 0·5 per cent sulphuric acid and 0·5 per cent potassium permanganate. After either of these procedures, the stratum corneum of epidermis and pancreatic beta-cell granules give a strong reaction with aldehyde-fuchsin. It is found, however, that both these elements are stained more intensely after oxidation with acidified permanganate than after periodic acid oxidation. In neither case do the hair shafts stain except for a weak reaction in the cuticle after permanganate oxidation.



Photomicrograph of section of mouse skin. The stratum corneum of the epidermis and the hair shafts are deeply stained. Mast cells and elastic fibres are also demonstrated. Bouin fixation, oxidation with peracetic acid for two hours, aldehyde-fuchsin, fast green F.C.F. as counter-stain. (× 100)

In later experiments, it was learned that, after oxidation for thirty minutes with acidified permanganate, the cortex of the hair external to the skin surface stains with aldehyde-fuchsin though the hair shafts within the skin remain unstained. On oxidation for one to two hours with peracetic acid, prepared as described by Pearse[1], both the stratum corneum and the hair shafts throughout their length are intensely stained. With shorter periods of peracetic acid oxidation, the stratum corneum reacts strongly while the hair shafts do not. These results suggest that the 'hard' keratin of the hair shaft is less susceptible to oxidation than the 'soft' keratin of the stratum corneum.

The greater resistance of hair shaft keratin to oxidation is also indicated by the results of Pearse[1]. He found that after performic acid oxidation the keratin of the hair shafts reacts more strongly with the Schiff reagent than does the keratin of the stratum corneum. As a possible explanation of this he noted that, since the Schiff reaction for keratin seems to depend upon the presence of the less oxidized sulphinic acid (alanine-β-sulphinic acid), it would appear that the further oxidation to the Schiff negative sulphonic acid (alanine-β-sulphonic acid) is more complete in the stratum corneum than in the hair shaft.

The results reported here show that aldehyde-fuchsin serves as an effective reagent for the demonstration of keratin after peracetic acid oxidation. The only tissue elements, besides keratin, which are stained in skin by this technique are mast cell granules and elastic fibres. There is none of the diffuse coloration which may occur with the Schiff reagent.

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Birefringence and Elasticity in Keratin Fibres

The long-range extensibility of wool and hair has been the subject of numerous investigations, in which changes in tension[1], X-ray diffraction pattern[2] and infra-red dichroism[3] have been studied during extension. The extent to which the elasticity of hair and wool may be considered rubber-like, and the interpretation of the changes in the X-ray diffraction pattern, have been the subject of considerable controversy[4]. In an attempt to cast new light upon the molecular mechanism responsible for the remarkable elastic properties of keratin fibres, the changes in birefringence extension have now been investigated and are described in this preliminary account.

Non-medullated human hairs of approximately circular cross-section were selected and degreased by successive extractions with cold petroleum ether. The extensions were performed in water on the stage of a polarizing microscope by means of a simple micro-extensometer. The extension ratio, α (stretched length/unstretched length), was determined by observing the separation, as measured with an eyepiece micrometer, of particles of carbon deposited on the scales of the hair. Retardation, Γ, was measured with a Berek compensator. Birefringence is defined as Γ/t, where t is the diameter of the fibre; but it is necessary to reduce the observed values to a common density, ρ_0, as Poisson's ratio is known to vary during extension. The observed birefringence must be multiplied by a factor $\sqrt{\rho_0/\rho}$, and since $\rho_0/\rho = \alpha t^2/t_0^2$ all values were reduced to a common density by use of the relation $n_{\parallel} - n_{\perp} = \Gamma\sqrt{\alpha}/t_0$, where t_0 is the initial diameter. Typical birefringence/extension curves are given in Fig. 1. Although the initial value of the birefringence differs from fibre to fibre, the fractional increase at any extension shows little variation. It is assumed in the following discussion that the observed birefringence is intrinsic, as no form birefringence has been detected by the usual methods[5]. The problem of impregnating keratin fibres with organic solvents of widely different refractive indices presents special problems, and is to be investigated further. Load/extension curves obtained under similar conditions of loading are given for comparison in Fig. 1.

Approximate birefringence values of 0·012 for the α-helix[6] and 0·032 for the pleated-sheet[7] configurations described by Pauling and Corey were calculated assuming a perfectly oriented protein fibre with density 1·3 and average residue weight 115. The contribution of the side-chains was neglected, although the C—C bond between the α and β carbon atoms was included. In view of the approximate nature of the calculation the use of co-ordinates for compound α-helices[8] was not justified. The method of calculation, due to Bunn, has been described by Seeds[9]; it is of limited application, however, as the values of the C=O and C—N bond polarizabilities used do not refer to the peptide linkage.

It would appear from the initial birefringence values observed in hair (*c.* 0·007) that a significant fraction of the keratin must be poorly oriented. This conclusion is supported by the low dichroism of the N—H modes observed by Ambrose and Elliott in the infra-red spectra of hairs[3,10], and the electron micrographs obtained by Mercer and Rees[11]. The increase in birefringence on extension is probably due, therefore, to the co-operation of crystalline fibrillar and amorphous matrix components. The increase of anisotropy

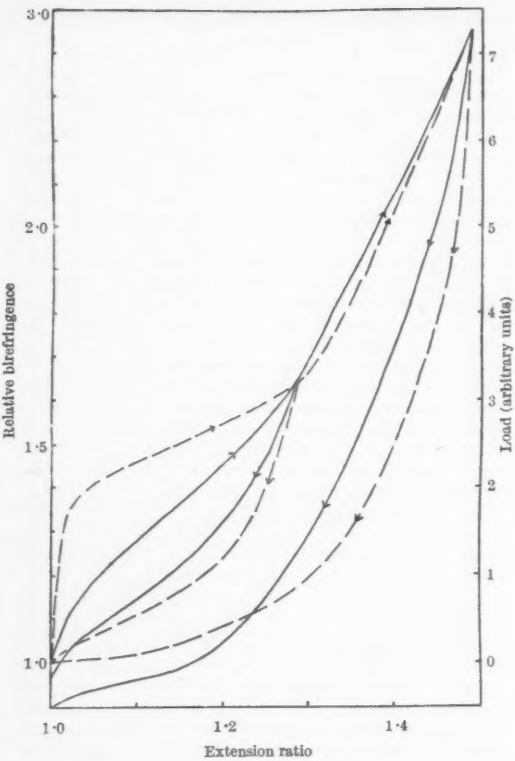

Fig. 1. Average values of birefringence (full curves) and load (broken curves) for about 30 per cent and 50 per cent human hair

in the matrix would be expected to contribute a small, approximately linear increase in birefringence with extension, as observed in rubber[12], for extension ratios up to 1·5.

An examination of the theoretical form of the birefringence/extension relationship for a number of idealized systems, including rubber-like behaviour[12] and crystallite orientation[13], reveals that all are approximately linear in the observed range of extension ratios. A pronounced change in slope may be considered, therefore, to involve a transition from one idealized behaviour to another. A process of disordering, for example, crystalline → amorphous, or cross-linked → free chains, will lead to a decrease in slope and vice versa.

From the high initial slope of the birefringence/extension curve we may suppose that an improvement in orientation or development of strain in the crystalline regions of the fibre is involved. In the range of extension ratios *c.* 1·02–1·20 a progressive reduction in slope indicates a transition to a less ordered system, probably involving a destruction of the crystallinity. This observation is in accord with the thermodynamic data of Bull[14] and Woods[15], who showed that the contribution of the entropy term to the stress in this range is negative, that is, the increasing entropy assists the extension process, and is also supported by the observation that progressive swelling of the hair occurs[16]. Further support is obtained from the hysteresis upon contraction, which is the reverse of that observed in rubber[12]. In hair there is a persistence of disorder leading to a lower value of birefringence on the return cycle.

At higher extension ratios the slope increases and becomes approximately linear, indicating a resumption of ordering upon extension with consequent decrease in entropy. This may be correlated with the positive contribution of the entropy term to the stress in this region[14,15]. The persistence of similar hysteresis implies that the destruction of crystallinity is not yet complete and the newly formed order decays rapidly.

The determination of each birefringence/extension curve took about an hour. It has been noted that birefringence decays slowly if the hair is held extended, and the hysteresis loop is diminished by rapid extension. The values of birefringence are not, therefore, either instantaneous or equilibrium values; but it is unlikely that this will affect the general conclusions drawn from the experiments.

From an isolated observation, Nutting *et al.* reported a 20 per cent increase in the birefringence of horse hair at 70 per cent extension[17]; in the present experiments a 150 per cent increase at 50 per cent extension was commonly observed. The large discrepancy may be due to a rapid relaxation of birefringence at high extensions in their measurements.

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Occurrence and Endodermal Origin of the Peritrophic Membrane in some Insects

The literature[1] on the occurrence, method of formation and function of the peritrophic membrane encircling the food in the midgut of many insects is extensive and contradictory. This is partly due to the lack of satisfactory criteria of what constitutes this membrane (the presence of chitin is the only commonly recognized feature) and partly to a rather widely held belief that the endodermal midgut is unable to produce a chitinous membrane.

Two different types of membrane are held to occur. One type arises from a ring of cells at the anterior end of the midgut which have been reported to be ectodermal in origin[2]. The second type is believed to arise by delamination from the surface of the general midgut epithelium, although this view is not universal. The membranes (of the second type at least) possess a fibrillar 'fish-net' structure, generally with less well-organized material overlying the net and filling the interstices[3]. The peritrophic membrane is thought to protect the midgut epithelium from damage by hard or sharp particles of food, and it is often stated to be lacking in most fluid-feeding insects.

By the use of a small glass boat contained in a miniature stainless-steel pressure vessel, the van Wisselingh test for chitin[4] has been applied both to highly organized and to more fragmentary membranes. Using a positive test for chitin as the criterion, a peritrophic membrane has been found to occur in many insects where it is generally believed to be absent, for example, in many adult Lepidoptera, in many adult Nematocera and Orthorrhapha (Diptera), in larval Dermestidæ and adult Carabidæ (Coleoptera), in some adult ants (Hymenoptera) and in *Gryllotalpa* (Orthoptera). A peritrophic membrane has also been reported from Corixidæ[5] (Hemiptera). The generalization that fluid-feeding forms lack a peritrophic membrane must now be modified. Furthermore, it is clear that a peritrophic membrane is possessed by many insects which have no occasion to protect their midgut epithelium against hard particles of food.

As reported by several previous authors[6], mosquitoes and many other blood-sucking Diptera form a chitinous membrane around the blood meal in the enlarged posterior midgut. If a second blood meal is taken before the first is digested, the new blood surrounds the first meal and a second chitinous membrane is, in turn, secreted around the entire mass. Since the anterior midgut is of much smaller diameter than the posterior midgut, the chitinous membrane must have been formed *in situ* in the latter region either as a result of delamination from the cell surface or of secretion of a fluid precursor which condenses around the food. This evidence clearly indicates that the endodermal midgut epithelium is capable of producing a chitinous membrane, and there is good evidence that this process also occurs in many other insects. The embryonic origin of the cells at the anterior end of the midgut which secrete the first type of membrane now requires re-examination, for it would be surprising if the loss by the endodermal midgut of the capacity to secrete a peritrophic membrane were so frequently accompanied by the assumption of this function by cells derived from the ectodermal foregut, particularly where one type occurs in the larva and the other type in the adult of the same species (for example, Culicidæ, Tabanidæ).

Since the peritrophic membrane is formed at the surface of midgut cells carrying a striated border it is an attractive theory[7] that the 'holes' in the nets correspond with the spaces occupied by the rodlets of this border during the formation and orientation of the fibrils constituting the nets.

The capacity to produce a delaminated chitinous peritrophic membrane appears to have been an attribute of ancestral insects, since primitive insects (Collembola, Thysanura) possess this capacity as also do other representative arthropods (*Peripatus* (Onychophora), some Chilopoda (Myriapoda), Cladocera (Crustacea)).

Further details of these investigations are in the press[7].

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Leucine - Isoleucine Content of Wool

The procedure described by Moore and Stein[1] for the chromatography of protein hydrolysates on columns of 'Dowex 50' permits a complete separation and estimation of leucine and isoleucine. This has not previously been possible with the methods of quantitative analysis which have been applied to wool. Martin and Synge[2], using a commercial merino 64's quality dry-combed top, prepared a leucine fraction from the acetylated hydrolysate by countercurrent extraction. They compared the optical rotation of this fraction with the rotations calculated for pure acetyl-L-leucine and acetyl-L-isoleucine, and estimated the total amount of leucine isomers present to be 7·2 per cent (leucine nitrogen as per cent total nitrogen) and the ratio of leucine to isoleucine to be approximately 4 : 1. Graham, Waitkoff and Hier[3] employed the microbiological method of Hier, Graham, Freides and Klein[4] to analyse an unspecified grade of wool and found the leucine isomers present to account for 8·3 per cent of the total nitrogen, with a ratio of leucine to isoleucine of 1·8 : 1. The figures quoted by these workers for the fourteen amino-acids which they determined are, in general, higher than those reported elsewhere (for example, Speakman[5]).

In the course of a total amino-acid analysis of 64's quality merino wool recently carried out in this laboratory, using the procedure of Moore and Stein[1], we have been able to separate completely and estimate the proportions of leucine and isoleucine present. The mean and standard error obtained from eight replicate analyses for each of these amino-acids are as follow :

Leucine	4·90 ± 0·12 per cent
Isoleucine	1·97 ± 0·05 " "
Total leucine isomers	6·87 ± 0·17 " "
Ratio of leucine to isoleucine	2·48 : 1

The total amount of leucine isomers present is therefore close to the figures recorded by Martin and Synge[2,6], but not to those quoted by Gordon, Martin and Synge[7]. The ratio of leucine to isoleucine differs considerably from those previously reported.

I wish to express my thanks to Mrs. H. M. Forss for technical assistance, and to Mr. W. B. Hall for help with the statistical analysis of the results.

A full account of this work will be published in due course.

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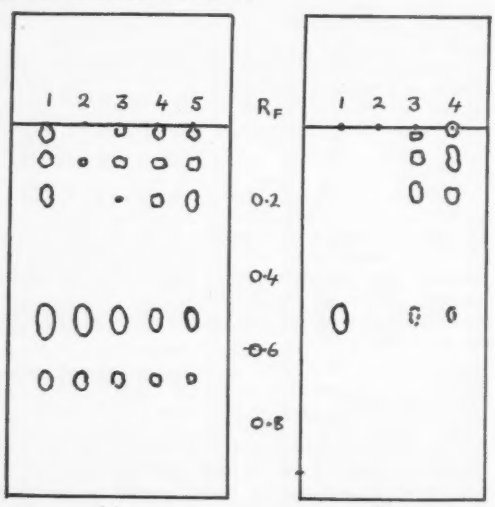
Chlorogenic Acid and the Enzymic Browning of Apples and Pears

Joslyn and Ponting[1] have recently stressed the meagreness of the information regarding individual phenolic compounds involved in the enzymic browning of fruits, although they suggested that chlorogenic acid was a possible substrate (cf. Ingraham and Corse[2]). Since chlorogenic acid is known to be acted on by the polyphenoloxidase of sweet potatoes[3], and to be widely distributed in many plant tissues including apples and pears[4], we have investigated its role in the enzymic browning of these two fruits.

Paper chromatograms run in butanol – acetic acid – water (4 : 1 : 5) of crude concentrated acetone extracts of Bramley's seedling apples show the presence of five fluorescent components when viewed in ultra-violet light in the presence of ammonia, three of which (R_F 0·02, 0·08 and 0·20) show only faintly (Fig. 1). The major compound (R_F 0·54) was separated by large-scale paper chromatography and shown to be chlorogenic acid by identity of R_F values in several solvents, colour reactions[5], and ultra-violet absorption spectra in ethanol and 0·002 *M* sodium ethoxide solution[6].



(*a*) (1) Crude acetate extract of apple tissue; (2)–(5) chromatograms of apple during course of browning

(*b*) (1) Chlorogenic acid; (2) apple enzyme extract; (3) mixture of (1) and (2) after reaction; (4) mixture of (1) and pear enzyme extract after reaction

When samples of the tissue are minced in phosphate buffer *p*H 6·7 and air is bubbled through the suspension, a rapid browning takes place. Chromatograms of the extract show that as browning proceeds the intensity of the compounds of low R_F value increases and that of chlorogenic acid and the other component decreases (Fig. 1,*a*). Tissues minced in the presence of ascorbic acid or thiourea in which no browning takes place show the presence of chlorogenic acid and the faster running component only.

Tests were carried out in phosphate buffer with pure chlorogenic acid plus either a suspension of minced tissue which had been pre-washed with acetone at – 20° C. until free of phenols, or the polyphenoloxidase extracted from it with 1 per cent sodium carbonate solution[7]. In both cases passage of air through the mixture gave rapid browning. Chromatograms of the mixture showed that the three compounds of low R_F values found above were produced during the course of the reaction (Fig. 1,*b*). When catechol was used as a substrate, no formation of the three slow-moving components was found, although strong browning was observed.

Similar results have been obtained with chlorogenic acid and an enzymic preparation from Conference pears. Thus it is apparent that chlorogenic acid is one of the substrates involved in the enzymic browning in both apple and pear, and that the three fluorescent compounds (R_F 0·02–0·20) are formed from it during the reaction.

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Glycogen in the Dividing Cells of the Liver of the Chicken Embryo

Von Gropp[1] has investigated the distribution of glycogen in hepatic cells of the rat after the administration of the carcinogen butter yellow (*p*-dimethylaminoazobenzol). Using Best's carmine technique and the periodic acid–Schiff sequence, he concluded that the amount of glycogen in dividing cells was considerably less than in non-dividing cells. It was further found that when individual dividing cells were examined glycogen was found in 84 of 200 cells (42 per cent), whereas it was present in nearly all the non-dividing cells. The same difference in the glycogen content of dividing and non-dividing cells has been recorded in a transplantable tumour of the rat liver by Strong and Smith[2]. This note records the results of equivalent investigations on the liver of the chicken embryo.

Glycogen can be demonstrated histologically in the liver of the chicken embryo at the end of the seventh day of incubation[3]. In the present investigations the liver was removed from the embryo during the eighth and ninth days and immediately fixed in Carnoy's fluid. Sections were stained for glycogen by the periodic acid – Schiff sequence, as described

Table 1. GLYCOGEN IN HEPATIC CELLS

Type of liver	Dividing cells		Non-dividing cells	
	Number examined	Per cent positive	Number examined	Per cent positive
Embryonic chick (8th day of incubation)	80	71	78	76
Embryonic chick (9th day of incubation)	91	80	82	71
Embryonic chick (9th day of incubation)	62	89	56	84
Adult rat treated with butter yellow (von Gropp[1])	200	42		nearly all

by Lillie[4], using control slides treated with saliva. Glycogen was found in the majority of non-dividing hepatic cells, mostly as 1–4 clumps about 2 μ in the longest diameter. In other cells it was in the form of fine granules and in some cases these granules were scanty. In the dividing cells, glycogen was found to have a similar distribution, and no difference could be detected in the glycogen content of dividing and non-dividing cells. To reinforce this subjective assessment the presence or absence of glycogen was determined in individual cells.

Sections were examined at a magnification of × 750. Whenever hepatic cells in division were observed the presence or absence of glycogen was determined in these cells as well as in a non-dividing hepatic cell selected at random in the same field. The results for three embryonic livers are recorded in the table. In all three cases it was found that more than 70 per cent of dividing cells contained glycogen, which is significantly greater than the 42 per cent recorded by von Gropp[1] in the rat liver after treatment with butter yellow. Furthermore, in the embryonic liver there is no significant difference in the proportion of dividing and non-dividing cells which contain glycogen. Thus the diminished glycogen content found in the dividing cells of the rat liver treated with a carcinogen[1] and also in a hepatic tumour[2] has not been found in the liver of the chicken embryo. This difference may be of importance since, in the liver, similarities have been suggested in neoplastic and embryonic tissue[5].

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Inhibitory Action of Cocaine

DURING a study of the inhibitory action of cocaine on cellular respiration, we found that the oxidations of added pyruvate by brain homogenate and by the respiring yeast, *Torulopsis utilis*, were inhibited to a similar degree, a 0·002-*M* concentration of the drug causing an inhibition of about 50 per cent in each case. It had previously been shown, using *Saccharomyces cerevisiae*, that the inhibition of fermentation by cocaine could also be attributed to the blocking of pyruvate metabolism, carboxylase being inhibited[1,2].

Further analysis with the view of discovering more precisely the site of respiratory inhibition gave results, details of which will be published elsewhere, which, when considered in conjunction with pharmacological evidence (anti-acetylcholine effect), suggested that cocaine interfered either with the activation of acetate or with the utilization of active acetyl groups. One line of investigation to test this theory was to study the effect of cocaine on the biosynthesis of citrate from acetate.

In experiments with yeast we followed the procedure of Weinhause and Millington[3], whereby citrate accumulates in an aerated suspension of starved bakers' yeast in 0·2 *M* magnesium acetate; the further metabolism of citrate being prevented by the magnesium inhibition of aconitase. Mixtures having an initial *p*H of 7, with and without cocaine, were aerated at 30°. Samples were withdrawn at intervals for the estimation of citrate by the method of Natelson, Pincus and Lugovoy[4].

In a typical experiment the following results were obtained:

	Time (hr.)	Citrate, μgm. per ml. yeast suspension	
		No cocaine	Cocaine, 0·001 *M*
a	0	38	38
b	1*	98	79
c	3	319	150
Synthesis during 2 hr. ($c - b$)		221	71

* The *p*H of the mixtures, determined electrometrically, was readjusted to 7 by addition of acetic acid.

In this experiment, during the two-hour period which falls in the most active stage of citrate synthesis, cocaine (0·001 *M*) inhibits the accumulation of citrate by 68 per cent.

Our results show that the toxicity of cocaine towards tissue respiration lies in the ability of the drug to block the entry of two-carbon fragments into the tricarboxylic acid cycle, either by a specific inhibition of the condensing enzyme or by preventing the formation of available active acetyl groups. The latter possibility is being further investigated.

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Hydrolysis of Esters by Extracts of Insects

O'BRIEN, in a recent communication[1], said that our remarks in the two publications to which he refers[2,3] could be interpreted as a statement that there was no choline esterase in adult *Tribolium castaneum* Hbst. or larvæ of *Tenebrio molitor* L. The relevant sentences (ref. 3, p. 496) are as follows: "Preliminary tests with preparations of whole *Tribolium castaneum* Hbst. and *Tenebrio molitor* L. failed to show any activity in hydrolysing acetyl choline. It should be pointed out that no persistent attempt was made to prepare an extract hydrolysing acetyl choline since these preparations were found to have considerable esterase activity in hydrolysing ethyl butyrate and *o*-nitrophenyl acetate. It is possible that with a

different technique these insects may prove a satisfactory source of choline esterase".

O'Brien states that our paper led Hopf[4] to believe that there was no choline esterase in adult *T. castaneum* and larvæ of *T. molitor*, but careful consideration of the paper shows that he interpreted our work to mean that esterases other than those which hydrolyse acetyl choline may be important in the insecticidal action of organo-phosphorus compounds, and indeed attached no theoretical importance to our inability to demonstrate the hydrolysis of acetyl choline in extracts of *T. molitor* and *T. castaneum* with the techniques which were then available to us. O'Brien further inferred that our publications indicated that we had used a percentage of alcohol in these preliminary tests, which is known to inhibit choline esterase activity, and had centrifuged the extracts and rejected the solids. No alcohol was used in the preliminary tests for choline esterase activity nor were the extracts centrifuged. The preparation to which he refers was used exclusively in the study of the inhibition of the esterases hydrolysing ethyl butyrate and *o*-nitrophenyl acetate, which are stable and soluble in the presence of a high percentage of alcohol.

We consider that the figures given by O'Brien for extracts of whole *Tribolium confusum* adults cannot be accepted as proof of similar activity in *T. castaneum* adults. Further, his figures for activity in both *T. confusum* adults and *T. molitor* larvæ are comparatively low and their significance is difficult to assess in the absence of the blank, which may be large (see Table 1). We ourselves have since been able to demonstrate hydrolysis of acetyl choline by extracts of parts of adult *T. castaneum* but not of the whole insects, or by whole *T. molitor* larvæ (see Tables 1 and 2). We believe that it is likely that enzymes hydrolysing acetyl choline also occur in the larvæ of *T. molitor*, although so far we have not been able to demonstrate them.

The main point of our communications was that, in insects, the study of the effect of organo-phosphorus compounds on esterases should not be limited to those hydrolysing acetyl choline; we did not wish to imply that we considered choline esterase activity unimportant. In fact, as part of a study of the anti-esterase activity of organo-phosphorus insecticides, we have been investigating the choline esterase activity of extracts prepared from a number of species and instars of insects.

Table 1. Hydrolysis of Esters by Extracts of Whole Insects

Species and stage	Carbon dioxide (c.mm.) liberated per gm. of insect in 30 min.		
	No added substrate	Acetyl choline chloride, $2{\cdot}76\times10^{-3}$ *M*	Phenyl acetate, $3{\cdot}66\times10^{-4}$ *M*
Tribolium castaneum Hbst. adults	124	160	960
Dytiscus fasciatus Sign. adult males	64	76	12,800
Tenebrio molitor L. adults	192	392	12,500
Blatella germanica L. adult males	58	470	1,560
Tenebrio molitor L. large larvæ	82	90	10,000
Phædon cochleariæ F. adults	400	362	—
Locusta migratoria L. adult	18	42	—
Oryzæphilus surinamensis L. adult	112	1,280	5,040
Diataraxia oleracea			
Last instar larvæ	82	82	—
2nd instar larvæ	52	136	—
Eggs (age in days)			
0–1	68	34	—
2–4	92	62	—
2–3	60	40	2,660
3–4	46	46	3,860
4–5	70	46	3,400
5–6	46	112	3,100
6–7	78	360	—

Table 2. Hydrolysis of Acetyl Choline by Preparations of *Tribolium castaneum* Hbst.

Treatment*	Carbon dioxide (c.mm.) liberated in 30 min. on the basis of 1 gm. of whole insect	
	No added substrate	Acetyl choline chloride, $2{\cdot}76\times10^{-3}$ *M*
Whole insect	124	160
Head	16	39
Head and thorax	78	190
Abdomen	50	50
Whole extract dialysed	112	370
Whole extract centrifuged		
Solids	82	276
Supernatant	90	90
Solids	66	300
Solids + supernatant	68	136
Solids + boiled supernatant	64	160

* Extracts were prepared in all cases by homogenizing with ice-cold water in an all-glass apparatus.

The use of crude extracts prepared by grinding whole insects with ice-cold water does not always yield preparations suitable for the measurement of the hydrolysis of acetyl choline by the Warburg technique. Our experimental technique was as follows. The insects were homogenized in ice-cold water and the activity was determined using the standard Warburg technique. The main vessel contained 0·5 ml. of 1 per cent sodium bicarbonate, an aliquot of extract, distilled water to make the total volume of fluid in the vessel to 3 ml.; 0·3 ml. of 0·5 per cent acetyl choline chloride was placed in the side bulb. The manometers were gassed with a mixture of 95 per cent nitrogen, 5 per cent carbon dioxide, and all determinations were carried out at 25° C.

In many cases a comparatively large amount of acid production occurs in the absence of added substrate, which may obscure the measurement of the hydrolysis of acetyl choline. Table 1 gives some comparative data on the hydrolysis of acetyl choline and phenyl acetate by crude insect extracts, and the rate of acid production in the absence of added substrate at the higher concentrations (usually of the order of 1 ml. of 20 per cent extract per manometer) required to observe the hydrolysis of acetyl choline. We do not have complete data on measurements of the rate of hydrolysis of phenyl acetate by this technique; but using other techniques we have readily demonstrated the hydrolysis of phenolic esters by all species tested. This includes all the species listed in Table 1. The ubiquity of the occurrence of this general esterase activity and its inhibition by organo-phosphorus insecticides suggest that it may be of importance in the action of these substances. This is supported by the apparent absence of choline esterase in the early stages of the eggs of tomato moth, which, as mentioned in our previous publications, can be killed in an early stage of development by concentrated tetraethyl pyrophosphate.

We must point out, however, that inability to demonstrate the hydrolysis of acetyl choline by crude extracts prepared under the mildest of conditions cannot be taken to indicate the absence of enzymes which hydrolyse acetyl choline, as is shown by extracts of *Tribolium castaneum* adults. The results appear to indicate the presence of an inhibitor in the extracts. In *T. castaneum* adults this appears

to be largely in the abdomen of the insect, since choline esterase activity could be demonstrated in the head, and head and thorax alone and not in the whole insect. Activity in the whole insect could be shown by dialysis, or by centrifugation, when choline-esterase activity is in the solids. The supernatant partially inhibits the activity of the enzyme in the solids (Table 2). The inhibitor is apparently heat stable, since boiling the supernatant does not destroy it. It is possible that an inhibitor also occurs in *D. fasciatus*, since there is no apparent choline esterase in whole crude extracts (see Table 1), but on dialysis the hydrolysis of acetyl choline may be observed, and in 30 min. 1 gm. of insects liberates 80 c.mm. of carbon dioxide in the absence of added substrate and 160 c.mm. in the presence of acetyl choline.

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Schottky Defects in Solid Solutions

In the various statistical thermodynamic treatments of substitutional solid solutions, it is tacitly assumed that the number of unoccupied lattice sites in the solution is either zero or the same as the number in the separated components. This assumption seems unsatisfactory on general grounds, and is, in fact, not supported by experiment. The nickel–aluminium system is in this respect a spectacular case, since at some compositions in the β-phase vacancies occur[1] in excess of 5 per cent. This system is, however, atypical in that, among other things, the vacancies seem to originate in special electronic effects, since the fraction of unoccupied sites varies with composition in such a way that the number of conduction electrons per unit cell is maintained constant. Schottky defects in alkali halide solid solutions have a simpler origin. The distribution over a group of lattice sites of two or more ions differing appreciably in size introduces stresses which lead to local lattice distortions and the occasional ejection of an ion.

In solid solutions of potassium and sodium chlorides, a maximum of 1·1 per cent Schottky defects was observed[2] for a solution in which the mole fraction of sodium chloride was 0·699. Thus in the solid solution vacancies are a hundredfold more abundant than in the pure salts. In solid solutions of potassium and sodium chlorides, the size difference is large and one expects extensive vacancies. It is of interest to note that vacancies are even more abundant in the potassium chloride and bromide system where the percentage difference in ion size is only one-fifth as large. The data are given in Table 1, where the measured densities are by Tammann and Krings[3] and the calculated results are from the unit cell dimensions reported by Oberlies[4]. Errors assigned to the densities were established by comparing the data on the pure salts either with other literature results or with quantities determined in this laboratory. The errors assigned exceed by at least a factor of 10 the precision claimed in the original

Table 1. Densities and Schottky Defects in Solid Solutions of Potassium Chloride and Bromide at 25° C.

Mole % KCl	Density (gm./cm.³)		% Schottky defects
	Measured	Calculated	
0	2·744 ± 0·006	2·744 ± 0·008	—
10	2·678 ± 0·006	2·680 ± 0·008	—
20	2·613 ± 0·006	2·610 ± 0·008	—
30	2·547 ± 0·006	2·543 ± 0·008	—
40	2·470 ± 0·006	2·475 ± 0·007	—
50	2·386 ± 0·006	2·403 ± 0·007	0·7 ± 0·4
60	2·304 ± 0·006	2·327 ± 0·007	1·0 ± 0·4
70	2·214 ± 0·006	2·247 ± 0·007	1·2 ± 0·4
80	2·124 ± 0·006	2·166 ± 0·006	1·9 ± 0·4
90	2·055 ± 0·006	2·081 ± 0·006	1·3 ± 0·4
100	1·994 ± 0·006	1·994 ± 0·006	—

publications. For the two cases cited, Schottky defects in the solid solutions are orders of magnitude more abundant than in the separate salts, and from general considerations it seems likely that this is the usual situation with most solid solutions.

All the binary alkali halide systems which have been studied[2,5–7] are endothermal with respect to their components, and the curve showing the heats of solid solution versus composition rises more steeply on the side of the component of smaller lattice constant than on the opposite end of the composition scale. This and a similar asymmetry in the solid-solution demixing curve[2,8] show clearly the expected behaviour, namely, that stresses are more acute when replacing a small ion with a large one than for the reverse process. Thus one is led logically to the notion that Schottky defects will be more extensive in the solutions which are richer in the smaller substituting ion. Not only is this trend apparent in the two salt systems cited but also it is followed[9] in the metallic system magnesium–cadmium, where geometrical factors are important (in this case shape difference rather than size difference is probably more important). Elsewhere it has been pointed out that the cadmium-rich solutions possess vacancies up to 2 per cent. Unpublished calculations indicate an undetectable percentage of vacancies in the magnesium-rich solutions. An interesting feature of this system is that the $MgCd_3$ superlattice contains 1·7 per cent Schottky defects which remain frozen-in at absolute zero and produce[10] a substantial departure from the third law of thermodynamics.

The existence of extensive vacancies in the system sodium–potassium chloride has received recent indirect confirmation by Hyvonen[11] and by Scheil and Stadelmaier[12] in studies of the kinetics of precipitation in it. In both investigations an activation energy at low temperatures of about 20 kcal. is found, which is close to the value required to move a vacancy[13]. If the vacancy must be formed and moved, an activation energy of approximately 60 kcal. is needed[13].

The foregoing remarks raise some interesting questions regarding recent and apparently successful attempts to calculate the energies of alkali halide solid solutions. Earlier efforts were unsuccessful because of failure to allow for lattice distortions. Wasastjerna[14] and Durham and Hawkins[15] have taken into account the energy reductions resulting from lattice distortions, and Wasastjerna in addition has evaluated the local-order parameter and made allowance for the reduction in energy due to departures from a random distribution. Both treatments were remarkably successful in accounting for the energies associated with the formation of potassium chloride–bromide solutions without allowing for the observed number of empty sites. If one can judge from the

energy required to create a vacancy in a pure salt, the energy difference between a sound potassium chloride–bromide lattice and one containing of the order of 1 per cent defects should be considerable. It therefore seems that the success of these theories is largely fortuitous.

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Low-Frequency Noise in the Range 0·5-20 cycles per sec.

In order to further understanding of magnetic fluctuations in the frequency range 0·5–20 cycles per sec., a programme was initiated by the Geophysics Research Directorate, U.S. Air Force Cambridge Research Center, in November 1949. The work done by Menzel and Salisbury[1] and by Willis[2] was continued with the view of obtaining correlation with other geophysical and solar phenomena.

The apparatus consists of a pick-up loop with an effective area of 257 sq. m., a battery-operated A.C. amplifier designed for flat response from 0·5 to 20 c./s. and a gain of 160 db., and a recorder originally made for seismographic work. The recorder, designed by R. L. Blumberg, has galvanometers flat to 40 cycles; chart speed is 1 mm. per sec.

The equipment is at Maynard, Massachusetts, in a concrete building made for ammunition storage. The loop, located approximately 150 ft. from the building, and the connecting cable are buried approximately one foot deep. A second site is located in the desert of New Mexico. Both sites are remote from power lines and were chosen for their low-noise characteristics.

Calibration of the amplifiers took place at least three times weekly. Fig. 1 illustrates the records obtained for a noise storm, a quiet period, and for calibration voltages.

Continuous recordings were maintained, and readings made hourly. An index for low-frequency noise was formulated by measuring the width of the base-level and reducing the readings to a uniform calibration of 10 mm. = 1·0 μV. Spike activity unaccompanied by an increase in base-level was usually transient. An index for solar radio noise (200 Mc./s.) was formulated in the same manner.

The existence of storms in the frequency-range under consideration seems indisputable. During some intervals of heavy activity, values of more than a hundred times that of quiet-period readings were recorded. These storms occur quite frequently and cannot be attributed to man-made disturbances. Very often periods of heavy activity were found to coincide with similar periods in other geophysical phenomena[3].

A definite diurnal variation exists in the low-frequency data, and this variation is very much like that of the magnetic K-indices from Cheltenham (Fig. 2). Points are plotted for every three hours. The low-frequency curve represents 350 days of data; the K-index curve represents 450 days.

In an attempt to determine whether or not low-frequency noise is of purely local origin, apparatus was set up at a second site near Alamagordo, New Mexico. Amplification and recording equipment was the same and operating procedures identical at the two sites. The pick-up coils, however, differed in characteristics, the coil at Alamagordo presenting an effective area approximately fourteen times greater than that at Maynard. The noise-level recorded at Alamagordo was considerably lower than that at Maynard. The analysis of the corresponding records has not been intensive; but the following results are indicated. A tentative diurnal variation has been established for Alamagordo from the data of one month and displays characteristics similar to those of the Maynard variation. The second result is a fairly close correspondence in sense, though not in magnitude, of the daily means at the two sites during a stormy period in August 1952. The storm can be divided into three major phases at both sites (Fig. 3).

A correlation and coincidence analysis was undertaken to determine interrelationships between low-frequency noise and other geophysical phenomena. Correlation coefficients of no significance were obtained between low-frequency noise and (1) ionospheric storminess and (2) Cheltenham K-index. Coincidence studies for low-frequency noise and (1) solar flares and (2) SID's revealed no direct relationship. A cross-correlation function was computed for low-frequency noise and solar radio noise (200 Mc./s.). A marked peak (0·57) occurs at $T_s = 29$. That is, there is a very significant correlation between what happens one day on solar noise at 200 Mc./s. and what happens on low-frequency noise

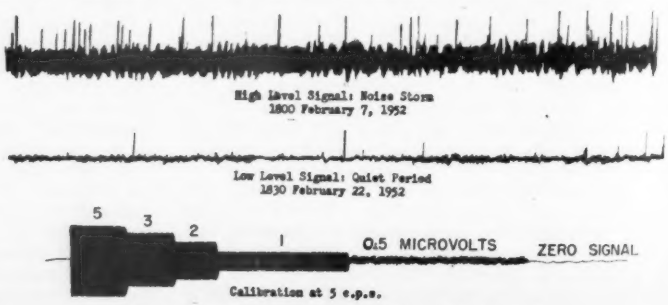

Fig. 1. Examples of various signal and calibration levels

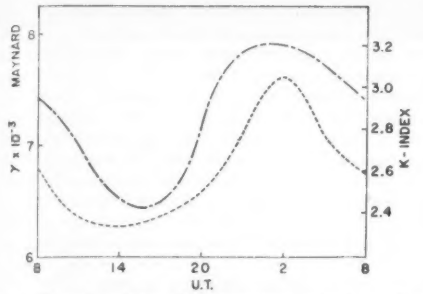

Fig. 2. Diurnal variation of low-frequency noise (.....) and magnetic *K*-index (— · — · —)

twenty-nine days later (Fig. 4). A tentative auto-correlation function was computed for the low-frequency data in case any internal cyclic tendency had escaped notice. There is a peak (0·44) at $T = 37$ days.

From the calculations made thus far, it would seem that the phenomenon under investigation is a real, non-spurious, low-frequency disturbance, and that this disturbance has a regular diurnal variation. In addition, several tentative results seem indicated. The disturbance would not seem to be entirely local in origin; the base-level activity in the low-frequency range resembles to some degree that of solar noise at 200 Mc./s. as recorded twenty-nine days earlier; and the diurnal variation of the low-frequency noise resembles that of magnetic *K*-indices. It is, of course, noteworthy that the lag between solar radio noise and low-frequency noise is within the range of the solar rotational period.

A detailed report of this experiment will be published elsewhere. Assistance rendered by Mr. Harley Baird in obtaining the data is acknowledged.

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U.S.A.F. Cambridge Research Center,
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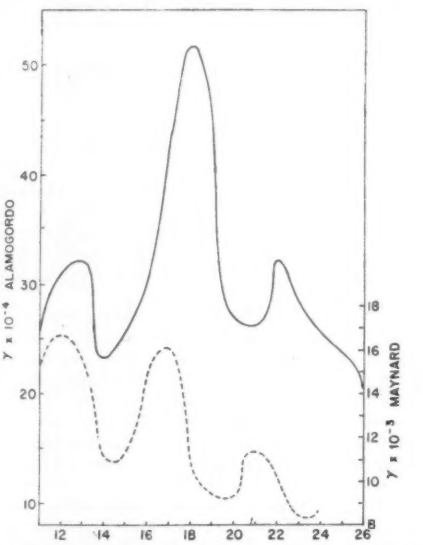

Fig. 3. Low-frequency noise, Aug. 11–26, 1952. ....., Maynard, Mass.; ——, Alamagordo, New Mexico

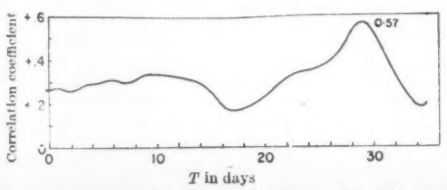

Fig. 4. Cross-correlation function between: solar radio noise at 200 Mc./s. (leading); low-frequency noise at 0·5–20 c./s. (lagging)

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Control of *Pseudomonas syringae* with Streptomycin

GLASSHOUSE experiments on the control of stone-fruit-blast (*Pseudomonas syringae* van Hall), a serious disease of stone-fruit trees in New Zealand, have recently been carried out using twenty-three proprietary therapeutants and five antibiotic substances at varying concentrations. Vigorously growing seedling peach trees (*Prunus persica* Sieb. and Zucc.) were used as test plants. With a sterile needle stems were lightly pricked at fifteen points and then sprayed with treatment solutions. After 1½ hr., by which time all plants were dry, they were sprayed with a 48-hr. beef–peptone–broth culture of a highly pathogenic strain of *Ps. syringae* and placed for three days in a cabinet at 12° ± 2° C. and approximately 90 per cent relative humidity. Since plants kept for a longer period in this cabinet regularly dropped their leaves, they were removed after three days and placed for seven days in a humidity cabinet where the temperature was 16° ± 6° C. and a water mist was automatically distributed for 35 sec. every 3½ hr. At the end of the ten days, number and length of lesions were recorded. Treatments were repeated on four different dates. By using the above technique a consistently high infection-rate was obtained, lesions developing at more than 85 per cent of damage points on check plants.

Materials used were as follow:

Bordeaux mixture (copper sulphate, hydrated lime, water)
'Copox' (copper oxychloride)
'Perenox' (cuprous oxide)
'Ialine' (colloidal copper)
'Venturicide' (phenyl mercury chloride)
'Ascospray' (phenyl mercury chloride)
'Thirospray' (tetramethyl thiuram disulphide)
'Fernasan B' (tetramethyl thiuram disulphide)
'Fermspray' (ferric dimethyl dithiocarbamate)
'Phygon XL' (2,3-dichloro-1 4-naphthoquinone)
'S.R.406' (*n* trichloromethylthiotetrahydrophthalimine)
'Murfixtan' (phenyl mercury salt of naphthyl methane sulphonic acid)
'Crag 658' (copper zinc chromate)
'Crag 5379' (1,2,3-trithio 5,8-diazacyclononane-4,9-dithione)
'Crag 5400' (α α trithiobis (*N* dimethylthioformamide))
'Manzate' (manganese ethylene bisdithiocarbamate)
'Dithane Z78' (zinc ethylene bisdithiocarbamate),
'Tetroc' (tetrachloro *p*-benzoquinone)
'Zirospray' (zinc dimethyl dithiocarbamate)
8-Quinolinol
8-Quinolinolate benzoate
Zinc 8-quinolinolate
Copper 8-quinolinolate
Streptomycin sulphate, 725 units per mgm.
Aureomycin hydrochloride, 550 μgm. per mgm.
Crude terramycin hydrochloride, 490 μgm. per mgm.
Chloromycetin, 750 μgm. per mgm.
Crystalline patulin

None of the proprietary therapeutants was highly effective under these conditions, the best being 'S.R.406'. Used at concentrations of 2 lb., 3 lb. and 4 lb. per 100 gallons water, lesions developed at 53 per cent, 60 per cent and 80 per cent of the inoculation points compared with 88 per cent, 93 per cent and 89 per cent respectively on check plants sprayed with water. At the highest concentration, 'S.R.406' caused considerable foliage damage. Of the antibiotic materials tested, streptomycin sulphate was outstandingly the best. On plants sprayed with streptomycin at concentrations of 250, 500 and 1,000 μgm. per ml., lesions occurred at only 16 per cent, 12 per cent and 10 per cent of the sixty inoculation points, compared with 87 per cent, 88 per cent and 93 per cent respectively on check plants. Streptomycin sulphate caused no damage at any concentration used. The average lesion-length on check plants was 3·1 mm. compared with 2·3 mm. and 1·3 mm. respectively on plants sprayed with streptomycin at 500 and 1,000 μgm. per ml. Aureomycin, while substantially reducing infection at 1,000 μgm. per ml. (20 per cent infection), was ineffectual at 500 μgm. per ml. (87 per cent infection) compared with 93 per cent and 100 per cent infection respectively on check plants.

It is particularly noteworthy that streptomycin sulphate has been effective when other materials accepted as therapeutants have not controlled the stone-fruit-blast bacterium. It is also of interest that several therapeutants gave less control at high concentrations than at low concentrations.

Further field and glasshouse experiments are in progress and will be reported elsewhere. I wish to thank Mr. M. H. Dye, Microbiology Section of this Division, for suggesting the use of, and for technical advice on, the antibiotic materials used.

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Effect of Antibiotics on the Growth of the Silkworm, *Bombyx mori* L.

Oral administration of antibiotics such as penicillin, streptomycin, aureomycin and chloromycetin is known to stimulate the growth of mammals[1] and birds[2]. So far, no analogous work appears to have been carried out with insects.

The beneficial action of the antibiotics has been attributed (*a*) to their activity in conditioning the composition of the intestinal flora[3], (*b*) to their potential role as possible growth-factors for the host[4], and (*c*) to their ability to increase, in some yet undiscovered manner, the biological efficiency of the animal as a converter of feed into body-weight[5].

Our earlier experiments with antibiotics were concerned with a study of their effect on the incidence of disease among batches of silkworm larvæ when they were fed with supplements of protein hydrolysates. They showed that penicillin and streptomycin bring about a significant increase in the body-weight of the larvæ when administered along with protein hydrolysates[6]. This work has now been extended to other antibiotics—aureomycin, terramycin and chloromycetin. Since these antibiotics have been known to influence the utilization of proteins by animals, extra supplements of nitrogen in the form of two types of amino-acid mixtures, corresponding in composition respectively to that of casein and silk fibroin, were also supplied to the larvæ treated with the antibiotics. Necessary control batches without the antibiotic and the supplements were maintained simultaneously.

The 'silk mixture' consisted of only the four major amino-acids of the silk fibroin, namely, glycine, alanine, serine and tyrosine, in approximately the proportion in which they are known to occur in the protein. The Mysore × C. Nichi-1 cross-breed larvæ after the third moult were selected for equal weight and size. Batches of ten larvæ were assigned in duplicate for each treatment, and each of the individual larvæ was reared separately in a glass cage of its own and fed by the 'sandwich' technique developed by us[7]. The maximum average weight attained by the larvæ, the average weight of the pupæ and that of the silk are given in the accompanying table.

The results show that, of the antibiotics tried, aureomycin and chloromycetin, when administered alone to the silkworm, give an increase of 9–10 per cent both in the body- and the pupal-weights. The output of silk, on the other hand, does not show a corresponding increase; on the contrary, there is a definite decrease of about 5–8 per cent. The amino-acid mixture corresponding in composition to casein, when administered alone, increases the body-weight by about 15 per cent, while the pupal-weight is raised by about 8·5 per cent. The increase in the output of silk is only 2·5 per cent.

When the antibiotics and the amino-acid mixture are given to the silkworm larvæ in combination, the maximum increase of larval- and pupal-weights attained earlier are not only maintained, but also there is a definite 8–14 per cent increase in the output of silk. A similar increase can be observed in the case of the amino-acid mixture corresponding in composition to that of silk also, although it is not so pronounced.

It would appear that antibiotics, when administered alone, shift the nitrogen metabolism of the silkworm in favour of increasing the body-weight at the expense of the precursors of silk. When, however,

	Average weight of 10 mature larvæ (gm.)			Average weight of 10 moisture-free pupæ (gm.)			Average weight of 10 moisture-free silk-shells (gm.)		
	Water	'Casein mix.' (10 per cent extra N)	'Silk mix.' (10 per cent extra N)	Water	'Casein mix.' (10 per cent extra N)	'Silk mix.' (10 per cent extra N)	Water	'Casein mix.' (10 per cent extra N)	'Silk mix.' (10 per cent extra N)
Mulberry leaf only	24·22	27·93	25·91	2·60	2·80	2·51	1·49	1·53	1·51
" " +aureomycin (25 mgm./kgm.)	26·76	27·89	26·91	2·84	2·60	2·51	1·41	1·70	1·55
" " +terramycin (25 mgm./kgm.)	22·58	24·49	24·66	2·71	2·61	2·52	1·48	1·34	1·50
" " +chloromycetin (50 mgm./kgm.)	26·56	29·15	27·31	2·83	2·79	2·52	1·37	1·61	1·60

an adequate quantity of extra nitrogen of high quality is provided, the precursors of silk are formed, as evidenced by the increased output of silk. This would mean that the antibiotics influence the nitrogen metabolism of the silkworm and achieve a better utilization of even the extra supplements of amino-acids. In the absence of the antibiotics, however, this supplemental source of nitrogen does not appear to be utilized for silk production, as can be seen from the table. The 'casein mixture' alone gives only 2·5 per cent increase in the yield of silk, whereas, with the antibiotics, the yield of silk is increased by 8–14 per cent.

The 'silk mixture' alone, being biologically inadequate in its composition, as compared with the 'casein mixture', shows a smaller increase in the larval growth. In combination with the antibiotics, however, increases of weight ranging from 11 to 12 per cent are obtained. It would appear that antibiotics can effect a better utilization of even a biologically inadequate source of nitrogen present in the feed of the silkworm.

Terramycin, either by itself or in combination with the amino-acid mixtures, does not appear to have any beneficial effect either on larval-growth or on silk-production.

Details of this work will be published elsewhere. Our thanks are due to the Central Silk Board, Government of India, for financial assistance, and to the Director, Indian Institute of Science, for his interest.

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Selection of the Oil Palm (*Elaeis guineensis*) in Africa

Hitherto, work on the selection of the oil palm in Africa has been directed chiefly towards increasing the pericarp content of the fruit, the hereditary behaviour of the relevant factors being comparatively well known as a result of the work carried out by the INEAC in the Belgian Congo. It would appear, however, that the production in weight of bunches has as yet been little improved. In large-scale plantations, blocks planted with seed taken from natural palmeries have, under similar conditions, given bunch-weight yields comparable with those obtained from blocks planted with selected seed. This lack of improvement in production in weight of bunches manifests itself particularly in a very wide variation in the yields of individual palms of the present varieties; indeed, this constitutes one of the main causes of the relatively low yields obtained from such plantations. With the view of reducing this wide variability in individual production, the possibility of eliminating mediocre producers in the nursery before field-planting has been investigated.

The basis of this investigation may be indicated as follows. Instead of considering the annual production or total growth of a palm, or group of palms, in terms of vegetative organs and reproductive organs, which are not strictly comparable, I have suggested that the annual production can be expressed with sufficient accuracy by a single figure, namely, the weight of dry matter in the different organs. This method of expressing the potential annual production is valid if groups of plants of the same age, belonging to the same variety and growing under similar conditions, are compared. Bearing in mind the distribution of the dry matter content between the different organs in young palms not yet in production on one hand, and that of producing palms on the other, it was concluded that, at a given time and under similar conditions, the young plants which produced the greatest quantity of leaf matter (that is, number of leaves × average leaf area) would be those which later would give bunch-weight yields above the average.

On this theoretical basis, investigations were made of producing palms to see if there was any correlation between the quantity of leaf-matter produced and bunch production. Six groups of palms, ranging from four years and less (onset of production) to 4–9 years old were investigated. From the collected results, it appeared (1) that there is a positive correlation ($P = 0{\cdot}02$) between bunch production and the number of leaves and spear leaves present in the crown of the palms during the first two productive years; (2) that this correlation disappears two years after the onset of production; and (3) that among very young palms (four years and less), as well as among young palms not yet in production, there is equally a positive correlation between the surface area of the leaf and the pinnæ on one hand and the number of leaves present in the crown on the other. Thus, taking into account the fact that the fronds and central spear in the crown visible at any given moment correspond to the number of fronds produced during the two previous years, it would appear that there is a marked positive correlation between the bunch production of a group of palms during the first two years of production and the quantity of leaves produced by this group during the two years *before* production started. The fact that in six-year-old and older palms, the crowns of which no longer contain any fronds produced before the onset of fruiting, this correlation no longer exists may be explained by the marked antagonism between the vegetative and fruiting developments.

Consideration of experimental results obtained by Mr. J. D. Ferwerda (agronomist of this Research Department) has led to the conclusion that the number of fronds produced before the onset of fruiting, or the potential production of fronds, is a constant genetical factor in a palm or group of palms. As, further, for a particular group of palms, there is a high positive correlation ($r = + 0{\cdot}9$) between the cumulative production of this group over two years and the average total yield during twelve consecutive years, the final conclusion may be drawn that there is a positive correlation between the quantity of fronds produced during a particular period before fruiting begins and the weight of bunches produced in later years. From the same results the conclusion has also been reached that there is a positive correlation between the potential frond pro-

duction of a group of palms before the onset of fruiting and the average precocity of the palms of the group.

The value of the criterion 'production of fronds during a particular period before the onset of production' having been determined, an easy method, enabling this to be put into practice, was sought. It should be borne in mind that, in large plantations, the number of plants produced per annum may reach several hundred thousand. On this account, an attempt was made to establish a correlation between the quantity of leaves produced during a given period and the height of the plant—in practice, the length of the most fully developed leaf. Actually, the length of the frond is the principal factor determining leaf surface, and, as shown above, this is correlated with bunch production. Observations on this point were made on seven series of nursery palms, 4–12 months old. These established the fact that whereas there is almost no correlation between the quantity of fronds produced during a given period of time and the height of the plants at four months, there is a very marked correlation ($P = 0{\cdot}001$) at twelve months (corresponding to an average height of the plants of $\pm$ 130 cm.). A rational selection can thus be carried out in the nursery, based on the existing correlation between the height of the plants at one year old and later production in the plantation, provided all other conditions in the nursery are equal.

From the observations made during this study, some inferences have been drawn regarding the antagonism between the vegetative development and the fruiting of palms. These and the corollaries implied would seem to suggest that this antagonism affects the number of fronds produced, the leaf area of the developing fronds, and the rhythm of development in the growing leaf. The evidence also indicates that the onset of production—mainly the active growth of the first female inflorescences—constitutes the opening of a critical period for the palm and creates a physiological disequilibrium which only completely disappears after two and a half years. The incidence of this physiological condition and the antagonism between fruiting and vegetative development have also thrown new light on the pathological condition known as 'little leaf'. Lastly, the criterion of selection in the nursery proposed here may be used to advantage in the selection and breeding of high-yielding palms, the procedure being essentially based on the hereditary transmission of gene-complexes.

This work will be published in full elsewhere.

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Wind-borne Dispersal of Potato-Root Eelworm

Since the potato-root eelworm *Heterodera rostochiensis* Woll. became established in the main potato-growing areas of England, it has been realized that this pest can be transferred from infested to free fields in many ways[1,2].

In Britain some of the main potato-growing areas, heavily infested with potato-root eelworm, are situated on deep, light, easily worked land. Some of these areas, such as the moss lands of south Lancashire, the peat lands of the Isle of Axholme, Lincolnshire, the fens of Kesteven, Lincolnshire, and parts of East Anglia, suffer severely from dust storms under certain climatic conditions. Recently, observations were made to ascertain the extent to which cysts of *H. rostochiensis* can be transported during these dust storms. Strachan and Taylor[3], in 1929, suggested the possibility of cysts being wind-borne; but no conclusive evidence has been obtained from work in Britain. Chitwood[4], in the United States, confirmed that cysts were borne with the wind, as he collected small numbers among detritus blown from an infested field on to the surface of snow covering an adjoining uninfested one. The maximum distance at which cysts were recovered was 935 ft. from the source of infestation.

In order to obtain further information concerning the part played by wind in distribution, three traps were erected in March 1953 at Wroot in the Isle of Axholme, Lincolnshire, at the edge of a field of light sand and peat which was known to blow readily. The eelworm infestation on this field was not heavy —eight viable cysts per 25 gm. The traps were of sheet metal, 15 in. square with a light bolting silk bag attached. These were placed so that the centres of the traps were 1 ft. 1½ in., 2 ft. 6½ in., and 3 ft. 11½ in. above ground-level. They faced south-west, the direction of prevailing wind which produces dust storms.

On March 28, 1953, such a storm developed. Most fields within an area of 10 sq. miles were blowing. The maximum wind recorded at a nearby aerodrome, three miles to windward of the traps, was 25 knots from a direction 260° from true north.

The results obtained by examining the three catches of soil are given in Table 1.

Table 1

Height of trap	Weight of soil (gm.)	Volume of soil (c.c.)	Fully viable cysts	Semi-viable cysts*	Non-viable cysts
6 in.–1 ft. 9 in.	20,012	17,798	2,077	1,870	9,598
1 ft. 11 in.–3 ft. 2 in.	3,125	3,860	435	567	2,666
3 ft. 4 in.–4 ft. 7 in.	768	970	103	128	447

* Semi-viable cysts containing less than fifty eggs.

Egg-counts made on five samples of cysts gave an average of 137 eggs and/or larvæ per viable cyst, 55·5 per cent being eggs and 44·5 per cent larvæ.

It would appear, therefore, that under the conditions of March 28, 1953, there was a considerable movement of cysts in blowing soil. The conditions existing were by no means exceptional, it being common to have five or six such windstorms each year. On this one day alone, at least 5,180 viable cysts moved over a front 15 in. wide and 4 ft. 6 in. high. This is equivalent to approximately 1,250,000 cysts over a 100-yd. front to a height of 4 ft. 6 in. Although most of these cysts travelled not more than 18 in. above the ground it is considered that they can be easily wind-borne from field to field, since these areas normally have few hedges or other natural windbreaks, the field boundaries consisting of shallow dykes over which soil passes on the wind without hindrance.

It is suggested, therefore, that in these well-defined areas of blowing soil, the agency of wind in bringing about local distribution of eelworm cysts is of con-

siderably greater importance than the accepted methods of spread, on implements, seed potatoes, etc.

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Siliceous Spicules in the Calcareous Sponge, *Leucandra johnstonii* (Carter)

Specimens of this sponge collected at Calf Sound, Isle of Man, were investigated for spicules, and for their arrangement in the body of the sponge. Six types of spicules were found, ranging from very large tetraradiates and triradiates to long slender and minute rod-like oxea[1]. When the acid test was applied to a slide with dried spicules, all except the long slender oxea dissolved. These oxea are present in large numbers, and are set vertically in a palisade round the osculum.

When mixed spicules are examined with a geological microscope, crossing of the nicols causes five of the spicule types to show up as iridescent bodies (calcite); but the long slender oxea disappear—they are isotropic, and probably composed of colloidal (opaline) silica. A sensitive chemical analysis gave a strongly positive test for silica.

So far as is known, in no other calcareous sponge have siliceous spicules been observed. I should be grateful for more specimens of the sponge in order that a full account can be prepared.

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The American Slipper Limpet (*Crepidula fornicata*) in Milford Haven

During a short survey of Milford Haven (July 27–30, 1953) for the purpose of assessing the possibility of reviving the oyster fishery, six American slipper limpets (*Crepidula fornicata*) were found in or near Pennar Gut, the estuary of the Pembroke River. *Crepidula*, a serious pest of oysters, had previously been recorded only from the east and south coasts of Britain[1]. The limpets, varying in length from about 12 to 50 mm., were found during approximately half an hour's examination of the shores uncovered at low water of a good spring tide. Much of the time was devoted to other tasks and undoubtedly more limpets would have been found in an intensive search. The limpets taken comprised four singles and one colony of two. Two of the isolated limpets were covering spawn. It has been suggested[2] that isolated females may be capable of self-fertilization, but this has not been proved experimentally. Since young males are actively motile, the possibility that these apparently isolated females had been fertilized by itinerant males cannot be excluded. The minimum size at which males may become sexually mature is not known, but it is certainly very small, probably less than 10 mm., and such tiny males are easily overlooked on the shore.

Pennar Gut was used in the years following the Second World War for laying up both merchant and naval ships, and is adjacent to Pembroke Dock. There is a ship-breaking yard on the opposite shore near Milford Haven. Evidence has been adduced[1] to show that a major factor in the spread of *Crepidula* has been the movement of laid-up naval and merchant ships, which may remain for several years in infested areas on the east and south coasts of Britain and later be transferred for refitting or breaking-up to other areas. Very frequently, such vessels carry mussels and slipper limpets on their bottoms, and as a result *Mytilicola intestinalis*, the copepod parasite of mussels, and *Crepidula* have reached new areas[1,3]. It is to be anticipated that, when a careful search is made, *Crepidula* will be found in the Firths of Forth and Clyde, at Londonderry, Barrow-in-Furness, and at other ports in South Wales, to all of which laid-up ships have been traced after periods in east and south coast ports.

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A Plasmodium in Common Indian Partridges

On routine examination of birds commonly found in the vicinity of Delhi during the winter months, a species of avian malaria parasite was observed in some wild partridges (*Francolinus pondicerianus interpositus* Hartert), a species widely distributed in many parts of India and locally known as 'titar' (Hindi).

Gametocytes and all stages of asexual forms were detectable in the erythrocytes. The parasite appears to resemble *P. polare* first found by Manwell (1935) in a cliff sparrow (*Petrochelidon lunifrons lunifrons* Say).

Infection was invariably found to be low; but it had always been possible to passage the infection to fowls and chicks by blood inoculation from partridges showing infection. This infection was later transmitted from partridge to fowl and from fowl to fowl through *Aedes aegypti*.

It is believed to be the first report on any plasmodial infection in Indian partridges.

The strain is now being maintained in fowls and further studies are in progress.

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Suckling Reflex in the Cat

For experimental purposes, some new-born kittens had to be reared in the laboratory away from the mother. Difficulties were encountered in inducing the kittens to accept milk administered by means of a glass pipette, until a way of evoking the suckling response was found. It was observed that slight pressure from the pipette applied to the premaxillary part of the palate invariably produced the suckling response which was maintained so long as the kitten was disposed to accept food. The main feature of this response is a slight protrusion of the tongue with side-to-side concavity of the dorsum, which assumes the shape of a shoehorn. The nozzle of the pipette is firmly grasped between the tongue and the premaxillary palate. The upturned margins of the more posterior part of the tongue press against the palate. A closed channel is thus formed within the oral cavity. The protruded tip of the tongue works up and down the side of the pipette in a milking action. Suction is created by alternate depression and elevation of the floor of the oral cavity along with the mandible, while the margins of the tongue and the palate together maintain the closed channel.

It will be noted that the mechanism described above differs from that in the human baby, in that the lips take no part at all in sealing the oral cavity off from the exterior. An oral sphincter of the human type does not exist in carnivores.

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A Human Blood-Group Gene Intermediate between *M* and *N*

While many blood-group antigens have, subsequently to their discovery, proved to be divisible into a number of sub-types, the *M* and *N* antigens have shown little tendency to be subdivided. Aberrant *M* and *N* antigens have from time to time been described and attributed to corresponding genes, sometimes characterized as M_2 and N_2, but both of these are extremely rare, with frequencies of the order of 1 in 1,000 in all populations hitherto tested. It was therefore with great surprise that we found examples of an abnormal *M* antigen and also of an abnormal *N* in a single English family. The results of our tests on members of this family are shown in Table 1. The sera used have each been tested with consistent results against very many—in some cases thousands—other red cell samples. The classification of the sera into positive and negative reactors with members of the C. family depends solely on tests on members of that family and on incomplete tests on one other unrelated person. All the tests have been carried out at least in duplicate, and in the case of Mrs. C. and K. C. tests have been done on separate blood samples at intervals of several months.

It will be seen that the red cells of Mrs. C. and P. C. react with all anti-*M* sera, but with only three out of twenty-four rabbit anti-*N* and two out of four human anti-*N* sera, while those of K. C. react with all anti-*N* sera and with all but one of twenty-one rabbit anti-*M*, and all but one of six human anti-*M* sera. The Henshaw and Hunter antigens[1] which form part of the *MNSs* complex were shown to be absent from the red cells of all five persons. The wife and daughter of K. C. were both shown to be of the normal genotype *NsNs*.

Table 1. Reactions of Red Cells of C. Family with Anti-*M* Anti-*N*, Anti-*S* and Anti-*s* Sera

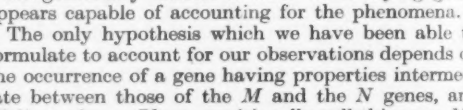
Specificity of sera	Anti-*M*		Anti-*M*		Anti-*N*		Anti-*N*		Anti-*S*	Anti-*s*
Origin of sera	Rabbit		Human		Rabbit		Human		Human	Human
Number of sera	20	1	5	1	3	21	2	*2	1	1
Red cells										
Mr. C.	+	+	+	+	+	+	+	+	+	+
Mrs. C.	+	+	+	+	+	−	+	−	+	+
A. C.	+	+	+	+	+	+	+	+	+	+
P. C.	+	+	+	+	+	−	+	−	+	+
K. C.	+	−	+	−	+	+	+	+	−	+

Accepting the stated relationships of the persons tested, the hypothesis of separate M_2 and N_2 genes occurring in the one family is genetically impossible, since K. C. must have obtained his normal *N* from his father and his abnormal *M* from his mother, who, however, has a normal *M* and an abnormal *N*. The occurrence of the very rare N_2 and of a mutation from *M* to M_2 in a single family is too highly improbable to be considered.

Samples of the anti-*M* sera which agglutinated the red cells of K. C. were absorbed with normal *M* and *MN* cells and were then found not to agglutinate the K. C. cells. This shows that the agglutination of the cells of K. C. cannot be due to an extra antibody in the anti-*M* sera, corresponding to some rare antigen independent of the *MN* system. It was similarly shown that the agglutination of the cells of Mrs. C. and P. C. was not due to an additional antibody in the anti-*N* sera.

No genetically tenable scheme of modifying genes appears capable of accounting for the phenomena.

The only hypothesis which we have been able to formulate to account for our observations depends on the occurrence of a gene having properties intermediate between those of the *M* and the *N* genes, and allelic to these. If we provisionally call this gene M^c, then it is assumed that red cells of genotype MM^c will be agglutinated by all anti-*M* sera and by some, but not all, anti-*N* sera, whereas those of genotype NM^c will be agglutinated by all anti-*N* sera but only by some anti-*M* sera. The gene M^c, being an allele of *M* and *N*, will be closely linked to *S* or *s*. Sera were fortunately available to test all members of the family with anti-*S* and anti-*s*, and the reactions of the cells of the five persons with each of these two sera provide a critical test of the hypothesis. The reactions of all members of the family can be accounted for in full by assigning them the genotypes shown in the accompanying diagram.



The *MNSs* genotypes of the C. family

The properties here attributed to the M^c gene are almost completely analogous with those of the c^v gene in the *Rh* system[2].

The agglutination experiments were supported by numerous titrations, and absorption and elution tests. The observations will be published in detail elsewhere.

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Golgi Bodies in the Male Germ-Cells of *Vaginula maculata*

Recent works of Baker[1] and Thomas[2,3] have revived Parat's[4] vacuome theory of the Golgi apparatus in an amended form. According to them, living cells contain spheroids stainable with neutral red, each spheroid being invested with a lipoidal pellicle. Thomas[3] has claimed to show that the dictyosomes and networks, produced in nerve-cells by methods involving the use of osmium tetroxide and silver nitrate, are caused by the over-impregnation of mitochondria and spheroids and unspecific precipitation of silver and osmium. Consistently with this view Baker has proposed a new term, 'lipochondria', to replace the 'Golgi apparatus', as nothing corresponding to the network originally described by Golgi exists in the living cell. Thomas[3] has attempted a comparison of the Golgi elements of the male germ-cells of gastropod molluscs and those of nerve-cells in the light of his own view of the structure of these inclusions.

The observations made by me on the cytoplasmic organelles of the male germ-cells of the pulmonate gastropod, *Vaginula maculata*, collected at Allahabad, offer no support to the interpretations of Thomas. Each male germ-cell of *Vaginula*, spermatogonium, spermatocyte, or spermatid, contains a single Golgi body, which is easily observable by ordinary microscopy, unstained and mounted in 0·7 per cent solution of sodium chloride. No part of this structure stains with neutral red, and the entire body colours with aqueous solution of methylene blue used in a concentration of 1 : 10,000. It does not appear to contain vacuoles, stainable or non-stainable with neutral red, in its substance. Instead, it is observed to be a spherical body consisting of a denser cortex and a thinner medulla—the externum and internum. In material treated according to Ludford's modification of Mann–Kopsch (the period of post-osmication being limited to three days), the Golgi element is observed to consist of a heavily blackened thin rim and an osmiophobe interior, the latter appearing homogeneous and slightly tinged black. There is no evidence that the osmiophobe part consists of collapsed vacuoles. In cases of heavy impregnation, small spherical objects are found attached to the externum and sometimes the entire structure becomes dense black.

Although neutral red solution never stains the Golgi element, neutral red bodies do appear in the cytoplasm in the neighbourhood of the Golgi element and elsewhere. These gradually increase in size with the passage of time and do not correspond to any elements that can be made out in the unstained, living cell. Baker[5] also has recorded that the vacuoles contained in the Golgi bodies of the male germ-cells of *Helix* are not stained with neutral red, and that this dye stains vacuoles elsewhere in the cytoplasm, which are not pre-existent.

Both Thomas and Baker use the term 'lepidosome' of Parat for describing the cortical part of the Golgi body. It may be mentioned, however, that Parat[4] used 'lepidosomes', or 'lepichondriosomes', to designate the dictyosomes of male germ-cells, because he believed that these structures (the 'dictyosomes faux'), which occur around and between the neutral red vacuoles, are specially modified chondriome ('chondriome actif') especially rich in their lipoidal contents. Parat[6] wrote: "Nous avons montré que parmi les éléments imprégnables dans cette zone il fallait distinguer les éléments vacuolaires que seul Perroncito s'est montré capable de imprégner et qui sont les *vrais dictyosomes* et ces éléments mitochondriaux hypertrophiés que l'on a appelés à tort dictyosomes ; nous leur avons donné le nom de *l'pichondriosomes* ou *l'pidosomes*". (Italics Parat's.) Since Baker and Thomas do not hold that the lipoidal pellicle of the spheroid is of mitochondrial derivation the use of this term is scarcely justifiable.

To the Golgi body of the male germ-cells of *Vaginula* this term is inapplicable. It is true that both the Golgi body and mitochondria become equally well impregnated in Mann–Kopsch preparations and that the Golgi body is stainable with acid fuchsin and Heidenhain's hæmatoxylin after fixation in such fluids as Champy's and Flemming's without acetic acid ; nevertheless, the two inclusions differ morphologically and histochemically. The Golgi element possesses a protein substratum as is shown by the fact that it persists after treatment with a fixative like Bouin's and afterwards stains distinctly with gentian violet and such-like stains. Not a trace of mitochondria remains in such preparations. The mitochondria stain with janus green *B* and take a distinct green colour, but not the Golgi element. The Golgi element colours with methylene blue solution, which leaves the mitochondria entirely unstained. Similarly, the Golgi element stains deep blue with aqueous solution of nile blue sulphate (about 0·01 per cent) but not the mitochondria. The mitochondria occur as spherules ; no chains and filaments are observed after colouring with janus green *B*.

Palade and Claude[7,8], who believe, on the basis of their own work on the homogenates of a wide variety of vertebrate somatic tissues, that "the Golgi apparatus is a gross artefact, namely, a myelin figure, or a complex of myelin figures", dismiss the Golgi bodies of male (and also female) germ-cells as "organelles peculiar to this specialized cell-line", one of the reasons adduced for this conclusion being that they (the Golgi elements of germ-cells) can be observed in the living cell. This comes very near to Schlottke's[9] attitude that the cytoplasmic inclusions of the various kinds of cells of even the same organism are not comparable—an opinion which has very little to recommend it.

A rather remarkable feature of spermioteleosis in *Vaginula* is the fact that an acrosome does not develop in the early spermatids at all. The Golgi body, which is present in the spermatogonium and spermatocyte in the part facing the external surface of the follicle, moves in the spermatid to the part of the germ-cell facing towards the centre of the follicle.

At the same time the nucleus, which occupied a central position in the spermatogonium and early spermatocyte, moves towards the outer side. As the spermatid becomes drawn out and elongated, the Golgi element is observed to lie in the middle of its body for some time, but soon it moves away towards the tail end. In the early spermatozoon the Golgi element breaks up, its parts gradually becoming indistinguishable from mitochondria. In the elongated spermatid, in which the Golgi body has moved to the posterior end, an acrosome can be made out as a barely distinguishable structure applied to the tip of the nucleus. There is no connexion between the Golgi body and acrosome.

Gatenby[10] has described an acrosome in the spermatids of *Limnæa stagnalis*. This acrosome is, however, figured as a thin ridge on the nuclear membrane of a spermatid and appears indistinguishable from it. In this respect, conditions in the spermatids of *Vaginula* and *Limnæa* appear to be similar. It is obvious, in any case, that the secretion of the acrosome cannot be the only function of the Golgi body, since in the spermatids of *Vaginula* there is quite a large Golgi element, but it takes no part in acrosome formation.

The mitochondria remain scattered haphazard throughout the course of spermatogenesis.

A detailed account will be published elsewhere.

M. D. L. Srivastava

Zoology Department,
Allahabad University,
Allahabad. May 16.

[1] Baker, J. R., *Quart. J. Micro. Sci.*, **85**, 1 (1944).
[2] Thomas, O. L., *Quart. J. Micro. Sci.*, **88**, 445 (1947).
[3] Thomas, O. L., *Quart. J. Micro. Sci.*, **89**, 333 (1948).
[4] Parat, M., and Painlevé, J., *C.R. Acad. Sci., Paris*, **179**, 612 (1924).
[5] Baker, J. R., *Quart. J. Micro. Sci.*, **90**, 293 (1949).
[6] Parat, M., *C.R. de L'Assoc. Anat.*, **23**, 383 (1928).
[7] Palade, G. E., and Claude, A., *J. Morph.*, **85**, 35 (1949).
[8] Palade, G. E., and Claude, A., *J. Morph.*, **85**, 71 (1949).
[9] Schlottke, E., *Z. Mikr.-Anat. Forsch.*, **24**, 101 (1931).
[10] Gatenby, J. B., *Quart. J. Micro. Sci.*, **63**, 445 (1919).

In Mann–Kopsch preparations, the cytoplasmic inclusion studied by Dr. Srivastava reduces osmium tetroxide and is thus blackened on the outside. Presumably it is mainly for this reason that he calls it a 'Golgi body'. Let us consider whether it is appropriate to apply the name of Golgi to a body having the characters described by Srivastava.

A wide variety of different objects in cells are sometimes blackened by the classical 'Golgi-techniques' (for example, the nuclear membrane, the cell membrane, mitochondria and granules of various kinds). It was in the nerve-cells of vertebrates that Golgi[1] described his apparatus. It is still uncertain whether there exists in the living cell a network that gives rise to the 'reticular apparatus' of classical Golgi preparations. Adamstone and Taylor[2] claim to have seen a network in the living nerve-cell of mammals by phase-contrast microscopy, though other careful workers have not succeeded in doing so. Let us assume, as a basis for discussion, that this network exists. Should we homologize Dr. Srivastava's *sphere* with this *network*? One can make the following statements about the supposed network of the nerve-cell of vertebrates with confidence:

(1) It is not easily observable by ordinary microscopy during the life of the cell.

(2) It is not stainable in life by methylene blue or nile blue.

(3) After fixation in Champy's fluid or in Flemming's fluid without acetic acid, it is not stainable by acid fuchsin nor by iron hæmatoxylin.

(4) After fixation with Bouin's fluid, it is not stainable by gentian violet.

Therefore, if the network exists, it is of an entirely different nature from the object studied by Dr. Srivastava. His work thus provides support for the suggestion I made recently in these pages[3] that cytologists should discontinue the use of the expressions 'Golgi apparatus', 'Golgi body', etc. Cytoplasmic inclusions of quite different kinds are being lumped together under Golgi's name.

John R. Baker

Department of Zoology and
Comparative Anatomy,
University Museum, Oxford.

[1] Golgi, C., *Arch. Ital. Biol.*, **30**, 60 (1898).
[2] Adamstone, F. B., and Taylor, A. B., *J. Morph.*, **92**, 513 (1953).
[3] Baker, J. R., *Nature*, **172**, 617 (1953).

Gregory's "Notæ in Isaaci Newtoni Principia Philosophiæ"

During a recent survey of the Gregory Collection presented to the University of Aberdeen by Sir Ian Forbes-Leith, Bart., of Fyvie, I came across a bound manuscript of David Gregory's "Notæ in Isaaci Newtoni Principia Philosophiæ". A page-by-page superficial collation of this manuscript with that presented to the University of Edinburgh by J. C. Gregory, the well-known professor of the practice of medicine, led me to the conclusion that it is a somewhat later copy of the Edinburgh manuscript, the differences noted being only such as were to be expected in copying. The fact that the Aberdeen manuscript is composite as to hand, paper and binding, and the presence of a few glosses in a hand distinct from those of the text, suggest, however, that it might be worth more detailed study; particularly in view of the fact that its existence was evidently unknown to Rigaud[1] or the writer of the notice of David Gregory in the Dictionary of National Biography.

Prof. H. W. Turnbull, to whom I communicated the discovery, tells me that he was unacquainted with any manuscript except that at Edinburgh, but that he believed that the original draft was lodged with the Royal Society. Through the courtesy of Sir Harold Hartley, I have now learnt that there is a manuscript with the title "Notæ in Newtoni Principia Mathematica Philosophiæ Naturalis". I hope to examine this, since if it is indeed the original draft, it is difficult to account for the fact that it is nowhere referred to in the literature. Rigaud seems to be referring to a manuscript other than the Edinburgh, but does not state its location. In the meantime, I should be very grateful for information as to the existence of any further manuscripts of the work, or other relevant details which might help to clear the matter up. I wish to acknowledge the courteous assistance given to me by Dr. Sharp and his staff, of the Library of the University of Edinburgh.

William P. D. Wightman

Department of History and
Philosophy of Science,
King's College,
University of Aberdeen. Aug. 10.

[1] Rigaud, S. P., "Historical Essay on the First Publication of Sir Isaac Newton's Principia", p. 98 *passim* (Oxford, 1838).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 12

UNIVERSITY OF LONDON (at University College Hospital Medical School, University Street, London, W.C.1), at 5.30 p.m.—Prof. E. G. D. Murray (McGill University): "A Surmise on Some Trends in Bacteriology".*

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the FINE CHEMICALS GROUP, SOCIETY OF CHEMICAL INDUSTRY, at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Prof. A. Albert: "A Fresh Approach to Heterocyclic Chemistry".

Tuesday, October 13

INSTITUTE OF METAL FINISHING (in the Regency Room, Charing Cross Hotel, London, W.C.2), at 3 p.m.—Dr. J. W. Cuthbertson: "Education and Research in the Metal Finishing Industry" (Presidential Address).

KING'S COLLEGE HOSPITAL MEDICAL SCHOOL (at Denmark Hill, London, S.E.5), at 5 p.m.—Prof. E. C. Dodds, F.R.S.: "Recent Knowledge of the Endocrine Background of Malignant Disease" (Dorothy Platt Memorial Lecture).*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

ILLUMINATING ENGINEERING SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Mr. W. R. Stevens: Presidential Address.

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Discussion of Published Papers on the "Physical Chemistry of Injection Moulding".

INSTITUTION OF THE RUBBER INDUSTRY, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 7 p.m.—Mr. J. Dow: "The Manufacture of Adhesive Tapes".

INSTITUTE OF ARCHÆOLOGY (at the Inner Circle, Regent's Park, London, N.W.1), at 8.15 p.m.—Prof. V. G. Childe: "The Orient and Europe" ("The Panorama of Prehistory in 1953", 1).* (Further Lectures on October 20, 27 and November 3.)

Wednesday, October 14

POSTGRADUATE MEDICAL SCHOOL OF LONDON (at Ducane Road, Shepherd's Bush, London, W.12), at 2 p.m.—Prof. A. C. Frazer: "Normal and Defective Fat Absorption".*

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. A. Smale: Chairman's Address.

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. F. P. Bowden, F.R.S.: "The Friction of Solids" (Redwood Lecture).*

THE PRESENTATION OF TECHNICAL INFORMATION, DISCUSSION GROUP (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 6 p.m.—Symposium on Aspects of Technical Writing. (1): Prof. R. O. Kapp: "The First Draft".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. R. G. Tomkins: "The Influence of Cultural Conditions on the Quality and Preservation of Fruit and Vegetables" ("Unsolved Problems in the Production of Food", 1).

WOOL EDUCATION SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Prof. J. B. Speakman: "The Preference for Wool: its Scientific Basis".

Thursday, October 15

INSTITUTION OF MINING AND METALLURGY (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Discussion of Papers on "The Technique of Mine Valuation in some Special Cases" and "The Underground Water Encountered at Blyvooruitzicht Gold Mine".

CHADWICK PUBLIC LECTURE (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 5.30 p.m.—Mr. C. J. Regan: "Air Pollution".*

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 6.15 p.m.—Dr. E. F. Gale: "Actions of Antibiotics in the Bacterial Cell".

CHEMICAL SOCIETY (in the Lecture Theatre, the Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Dr. J. S. Anderson, F.R.S.: "The Mechanism of Reactions between Gases and Solids" (Tilden Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. Norman White: Presidential Address.

Friday, October 16

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—General Meeting.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Literary and Philosophical Society, Newcastle upon Tyne), at 6.15 p.m.—Prof. E. V. Telfer: "Ship Model Correlation and Tank Wall Effect".

Saturday, October 17

BIOCHEMICAL SOCIETY (in the Department of Chemical Pathology, Westminster Hospital Medical School, Horseferry Road, London, S.W.1), at 11 a.m.—Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. David Rapaport (U.S.A.): "Theory and Investigation of Memory and Learning Reconsidered".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

HEAD (with degree in civil engineering or A.R.I.B.A.) OF THE DEPARTMENT OF CIVIL ENGINEERING AND BUILDING—The Principal, Wigan and District Mining and Technical College, Wigan (October 15).

LECTURER (with degree or equivalent and teaching and industrial or research experience) IN AIRCRAFT STRUCTURES—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (October 16).

LECTURER (with good honours degree and postgraduate experience in physical chemistry, and suitable teaching experience) IN PHYSICAL CHEMISTRY, in the Department of Chemistry and Biology, Leeds College of Technology, Leeds—The Chief Education Officer, Education Offices, Leeds 1 (October 16).

I.C.I. RESEARCH FELLOWSHIPS IN INDUSTRIAL RELATIONS—The Secretary of the University Court, The University, Glasgow, W.2 (October 17).

SENIOR LECTURER (with high academic and research qualifications) IN ORGANIC CHEMISTRY—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (October 21).

LECTURER (woman) IN THE DEPARTMENT OF EDUCATION—The Registrar, University College of Wales, Aberystwyth (October 24).

ASSISTANT ENGINEER (A.M.I.C.E., and preferably with a degree in engineering) IN THE NATIVE ENGINEERING DEPARTMENT, Southern Rhodesia Government—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (October 30).

CHAIR OF PHYSICAL CHEMISTRY—The Registrar, The University, Nottingham (October 31).

LECTURER (well qualified in pure or applied science, and experience in the gas or other branches of the fuel industries, and preferably with a knowledge of oil technology) and an ASSISTANT LECTURER (well qualified in pure or applied science, and preferably with industrial experience) IN GAS ENGINEERING AND FUEL TECHNOLOGY—The Registrar, The University, Leeds 2 (November 2).

SENIOR LECTURER IN PHYSICAL METALLURGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 6).

SENIOR LECTURER IN PHYSICAL METALLURGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 6).

NUFFIELD RESEARCH FELLOW IN ORAL BIOLOGY—The Registrar, The University, Leeds 2 (November 9).

CHAIR OF LOGIC AND METAPHYSICS, CHAIR OF BOTANY and CHAIR OF GEOLOGY—The Secretary, Queen's University, Belfast (November 20).

SCIENTIFIC OFFICER (Biochemistry) for research in problems in children—The Secretary, Queen's University, Belfast (November 30).

LECTURER IN BIOLOGY and a DEMONSTRATOR IN BIOLOGY (with honours degree, with zoology as the principal subject) in the Department of Zoology and Comparative Anatomy—The Dean of the Medical College, St. Bartholomew's Hospital, London, E.C.1 (December 1).

ASSISTANT METEOROLOGIST (with H.S.C. or equivalent in mathematics or physics, and preferably with forecasting experience) with the Mauritius Government—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33530/TA.

ENGINEER (preferably with honours degree in engineering or physics) IN THE TELEVISION SECTION of the Designs Department, to take charge of design of major items of equipment used in television studios and control rooms; and able to produce original work—E.E.O., B.B.C., London, W.1, quoting E.782.

ENTOMOLOGIST (with sound knowledge of methods of biological assessment and capable of undertaking specialized research) with the Pyrethrum Board of Kenya, to take charge of Biological Laboratories in Nakuru, and lead an entomological team working in conjunction with chemists on problems connected with the pyrethrum industry—Box "SE/82", c/o 95 Bishopsgate, London, E.C.2.

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS (with at least H.S.C. (science) or equivalent, and further qualifications in mechanical, electrical or electronic engineering, physics or mathematics may be an advantage) at the Royal Aircraft Establishment, Guided Weapons Department, Farnborough, for work on design, development and performance on new weapons and associated guidance and control systems; instrumentation of flight trials and investigation of trial results—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.232/53A.

FISHERIES OFFICERS (preferably with honours degree in natural science with emphasis on biology) in Nigeria, to demonstrate and develop simple fish farming in collaboration with a Fish Farmer and to investigate the relative suitabilities of different techniques—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.149/14/02.

MECHANICAL ENGINEERS (with good general engineering design experience, preferably in chemical plant or power plant); ELECTRICAL ENGINEERS (with wide experience in preparing specifications for the installation of electrical services, and preferably in the supervision of installation work); INSTRUMENTATION AND CONTROL ENGINEERS (with wide experience in the design and installation of control and recording circuits and servo-mechanisms), to assist in the design, construction and development of nuclear reactors—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berks, quoting "Eng. 93/53".

METEOROLOGIST (with university degree in mathematics or physics, or equivalent qualifications, and extensive forecasting experience, preferably tropical, for aviation and agricultural purposes, and sound knowledge of all duties in a territorial meteorological service) in Nyasaland, for organization and administration of aviation, weather and public forecasting service at Blantyre airport, and research into problems arising from the development of the meteorological service—The Director of Recruitment (Colonial Office), Sanctuary Buildings, Great Smith Street, London, S.W.1.

METEOROLOGIST (with first- or second-class honours degree in physics or mathematics, and two years experience in aviation forecasting) in Northern Rhodesia—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.57/3/01.

PHYSICISTS and ENGINEERS, (*a*) SCIENTIFIC OFFICER grade (with first- or second-class honours degree or equivalent in physics or engineering) for research and development in connexion with gyroscopic and allied instruments, Ref. A.247/53A; (*b*) and (*c*) EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER grades (preferably with practical experience of development in light mechanical or electro-mechanical field) to assist in above duties, Ref. A.248/53A; (*d*) EXPERIMENTAL OFFICER grade (with H.S.C. (science) or equivalent, but H.N.C. or degree in physics may be an advantage) for research and development, mainly in photographic optics, Ref. A.249/53A, in the Instrument and Photographic Department, Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

PRINCIPAL and SENIOR SCIENTIFIC OFFICERS (with first- or second-class honours degree in mechanical engineering with metallurgical experience, or first- or second-class honours degree in metallurgy with engineering experience), at the Atomic Energy Research Establishment, Harwell, for fundamental studies of nuclear reactor design, involving assessment of metallurgical and materials problems relative to engineering design requirements—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.529/53A.

RESEARCH ASSISTANT and a RESEARCH STUDENT (honours graduates in science and engineering) to work on physical problems connected with the combustion of droplets—The Registrar, Imperial College, London, S.W.7.

RESEARCH FELLOW IN SUGAR CHEMISTRY in the Department of Sugar Chemistry and Technology, Imperial College of Tropical Agriculture, Trinidad—The Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2.

SCIENTIFIC OFFICER (with honours degree in biochemistry or physiology, and preferably with previous experience in biological research) IN THE NUTRITION DEPARTMENT of the National Institute for Research in Dairying, to take part in work that will include the determination of the biological value of proteins, the study of calcium and phosphorus metabolism using radioactive tracers, vitamin D assays and general nutritional experiments with rats—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/16.

SCIENTIFIC OFFICERS and SENIOR SCIENTIFIC OFFICERS (with first- or second-class honours degree or equivalent, in physics, mathematics or engineering, and for the senior grade, at least three years post-graduate research experience) for project assessment groups at the Royal Aircraft Establishment, Farnborough, and at London Headquarters—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.161/53A.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (with first- or second-class honours degree in mathematics or astronomy, and an interest in celestial mechanics, spherical astronomy or numerical computation, and preferably with research experience in at least one of these subjects) IN H.M. NAUTICAL ALMANAC OFFICE, Royal Greenwich Observatory, Herstmonceux, Sussex, for work in the fields of celestial mechanics and positional astronomy—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.252/53A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Memoirs of the Society for Endocrinology. No. 1: The Thyroid Gland. Edited by P. Eckstein and Z. Zuckerman. (Proceedings of a Symposium held jointly by the Society for Endocrinology and the Endocrinological Section of the Royal Society of Medicine, at the Royal Society of Medicine, London, on 25 February 1953.) Pp. 48+4 plates. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 3*s*. to members; 5*s*. to non-members. [227

The Admiralty Ship Welding Committee. Report No. R.8: S.S. Ocean Vulcan Sea Trials, the Forces Acting on the Ship at Sea. Pp. viii+175+17 plates. (London: H.M. Stationery Office, 1953.) 35*s*. net. [237

Crookes Vitamin Index. Second edition. Pp. 22. (London: Crookes Laboratories, Ltd., 1953.) [237

Ministry of Education: Science Museum. Hand List of Short Titles of Current Periodicals in the Science Library. Seventh edition. Pp. 388. (London: H.M. Stationery Office, 1953.) 10*s*. net. [237

The Institution of Metallurgists. The Joining of Metals. (Lectures delivered at the Institution's Refresher Course, 1951.) Pp. 174. 14*s*. The Metallurgy of the Rarer Metals. (Lectures delivered at the Institution's Refresher Course 1952.) Pp. 156. 15*s*. 6*d*. (London: Institution of Metallurgists, 1952–53.) [277

Science, Humanity and Peace. Pp. 15. (London: Science for Peace, 1953.) 6*d*. [277

The 30th and 31st Reports of Gresham's School Natural History Society. 1952 and 1953. Pp. 46+4 plates. (Holt: Gresham's School, 1953.) 2*s*. [277

Ministry of Agriculture and Fisheries. Bulletin No. 10: Calf Rearing. Pp. iv+28. Third edition. (London: H.M. Stationery Office, 1953.) 1*s*. 3*d*. net. [277

The Imperial Forestry Institute, University of Oxford. Twenty-eighth Annual Report, 1951–52. Pp. 28. (Oxford: The Holywell Press, Ltd., 1953.) [277

Scientific Proceedings of the Royal Dublin Society. Vol. 26 (N.S.) No. 8, June 16, 1953: The Carboniferous Rocks Near Garristown, Co. Dublin, and in the Adjacent Part of Co. Meath. By John E. Scanlon. Pp. 145–156+1 plate. 4*s*. Vol. 26 (N.S.). No. 9, June 26, 1953: Trout in Lough Rea, Co. Galway. By Ann Healy. Pp. 157–164. 2*s*. (Dublin: Royal Dublin Society, 1953.) [277

British Museum (Natural History). Ruwenzori Expedition 1934–5. Vol. 3, Nos. 11–13. Coleoptera. (11) Chrysomelidæ. By C. E. Bryant. (12) Cerambycidæ. By E. A. J. Duffy. (13) Carabidæ: Peryphus. By P. Basilewsky. Pp. 151–177. (London: British Museum (Natural History) 1953.) 5*s*. [277

British Museum (Natural History). Great Barrier Reef Expedition, 1928–29. Scientific Reports. Vol. 6, No. 4: Hydromedusæ. By Dr. P. L. Kramp. Pp. 259–322+2 plates. (London: British Museum (Natural History) 1953.) 20*s*. [277

Other Countries

Bulletin of the Auckland Institute and Museum. No. 3: New Zealand Pollen Studies. The Monocotyledons; a comparative account. By Lucy M. Cranwell. Pp. 91+9 plates. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1953.) 32*s*. 6*d*. net. [207

Arteriosclerosis. By Dr. Jose Frolmovich S. Pp. 218. (Valparaiso: Dr. Jose Frolmovich S., Pedro Montt, 2407, 1952.) [237

Nigeria. Annual Report on the Forest Administration of Nigeria for the Year 1951–52. Pp. 38. (Lagos: Government Printer; London: Crown Agents for the Colonies, 1953.) 9*d*. net. [237

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